

VISIT...

LANZAROTE
Caliente.COM

Copiapoa

and their Environment

2006

Rudolf Schulz



Copiapoa. krainziana and *C. haseltoniana* (mountain form) growing at 800 m above San Ramon with Mt Perales in the background.



C. dealbata, growing north of Carizzal Bajo.

Copyright 2006. Rudolf Schulz

All rights reserved. No part of this book may be reproduced in any form or by any means without prior permission in writing.

ISBN 0 958516???

Schulz Publishing
Box 40, Teesdale, VIC 3328, Australia
www.tarrex.com
tarrex@ozemail.com.au

Acknowledgements

Attila Kapitay, Brian Gerrard, Leo van der Hoven, Paul Hoxey, Ricardo Keim, Paul Klaassen, Tom Knappic, Woody Minnich, Benjy Oliver, Ingrid Schaub, Anne Shein, Gustavo Valdés, Ian Woolnought

Preface

To write



Copiapoa echinoides, growing alone in a wide alluvial valley near Bahia Salada (27°40'S 70°54'E).

Contents

Introduction

6



North of Izcuna

10

Copiapoa ahremephiana
Copiapoa atacamensis
Copiapoa decorticans
Copiapoa solaris

Copiapoa tenuissima
Copiapoa tocopillana
Copiapoa sp. aff *paposoensis*



Izcuna to Taltal

32

Copiapoa albispina
Copiapoa cinerea ssp. *cinerea*
Copiapoa haseltoniana
Copiapoa humilis
Copiapoa humilis ssp. *varispinata*

Copiapoa olivana
Copiapoa krainziana
Copiapoa montana
Copiapoa paposoensis

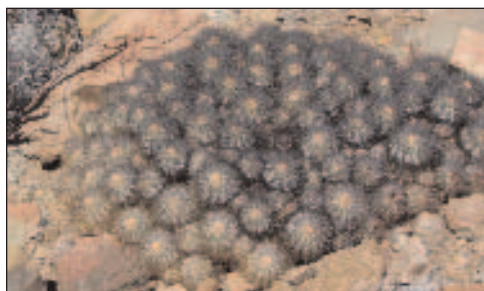


Taltal to Chanaral

58

Copiapoa cinerascens
Copiapoa cinerea ssp. *columna-alba*
Copiapoa desertorum
Copiapoa grandiflora
Copiapoa sp. 'Guanillos'
Copiapoa laui

Copiapoa longistaminea
Copiapoa marginata 'Bridgesii'
Copiapoa mollicula
Copiapoa rupestris
Copiapoa serpentisulcata
Copiapoa taltalensis

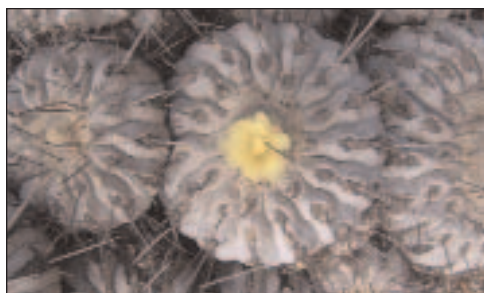


Chanaral to Caldera

90

Copiapoa calderana
Copiapoa chanaralensis
Copiapoa cinerascens
Copiapoa hypogaea

Copiapoa marginata
Copiapoa sp. 'Leonensis'
Copiapoa sp. 'Quebradesa'



Caldera to Huasco

116

Copiapoa dealbata
Copiapoa echinata
Copiapoa echinoides
Copiapoa fiedleriana

Copiapoa humilis ssp. *longispina*
Copiapoa megarhiza ssp. *megarhiza*
Copiapoa megarhiza ssp. *borialis*

South of Huasco

140

Copiapoa coquimbana in its many forms.
Copiapoa humilis ssp. *australis*
Copiapoa sp. aff *coquimbana*



Then and now

158

Photographs from the past re-photographed to show the changes.

<i>C. solaris</i>	1972 and 2003
<i>C. columna-alba</i>	1968? and 2005
<i>C. longistaminea</i>	1996 and 2005
<i>C. haseltoniana</i>	1996 and 2005
<i>C. columna-alba</i>	1994 and 2004



The flowering desert

170

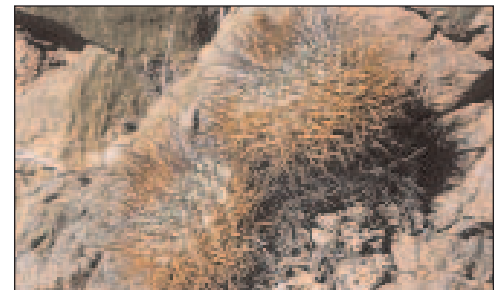
The effects on the vegetation in the copiapoa environment during years with wet winters.



Photographic library

182

A selection of my favorite plants and locations.



Plants in cultivation

204

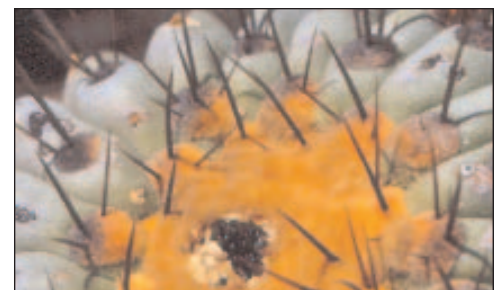
From seedlings to advanced plants



Appendix

214

Species lists
Taxonomic possibilities
Recommended reading





▲ *C. coquimbana* is the most common species of Copiapoa in Chile. This southernmost species grows from near sea level (this photo) to high up in the coastal hills (below). Many of the differences seen in these two plants are due to environmental conditions.

▼ *C. coquimbana*, growing at 1350 m in elevation some 55 km?? inland from the coast near Vallanar.



Introduction

Ten years have elapsed since 'Copiapoa and their Environment–El Cobre to Chanaral' was published in 1996. Seven visits by the author have shed new light on many copiapoa issues covered in this book as well as provided opportunities to research those species not covered in 'Copiapoa 1996'.

In this book all of the copiapoa species are covered in six geographic-based chapters. While there is some overlap in distribution, most species are endemic to one sector. The northernmost chapter contains six good species as well as one possibly new taxon. The sector from Taltal north to the Iszuna valley deals mostly with the same species as covered in 'Copiapoa 1996'. Species not covered were *C. olivana*, *C. montana* and *C. paposoensis*. This sector contains the most commonly grown plants seen in cultivation. The sector from Taltal south to Chanaral was also covered in 'Copiapoa 1996'. It contains twelve taxa of which *C. mollicula* and *C. taltalensis* were not covered in 'Copiapoa 1996'. The area between Chanaral and Caldera contains five well known species, and two new taxa. The sector from Caldera to Huasco contains six species. The last sector south of Huasco contains most of the forms of *C. coquimbana* as well as a very small population of the newly described *C. humilis* ssp. *australis*.

Some of the points of the field work which are included are:

1. The re-discovery of the type populations of Friedrich Ritter's *C. chanaralensis*, *C. montana*, *C. humilis* 'Barquitenensis' and *C. paposoensis*.
2. Examination of two taxa (*C. sp.* 'Quebradesa' and *C. sp.* 'Leonensis') which do not fit well into any existing species descriptions. Both taxa, while having a wide distribution, apparently unknown to Ritter and will be published by Ricardo Keim and Ingrid Schaub as new taxa in 'Cactus and Co' (2006).
3. Documenting the extent and variability of *C. cinerascens*. This species is best known from Pan de Azucar National Park. The populations to the south vary considerably and have an extensive distribution along the inner coastal hills.
4. Exploring and extending the published distribution for *C. marginata* which was found in a large area extending 20 km inland at elevations of at least 1400 m.
5. Documenting growth via 'before and after' photographs to show how the plants change over time.
6. Measuring temperatures experienced by two copiapoas for twelve months with the use of a data logger.

Insights based on visits to habitat need to be viewed in perspective. Each visit is only a single 'snapshot' taken within a movie which

has been running for tens of thousands of years. Each time we have visited copiapoa habitats, conditions have differed from previous visits. Conclusions based on only a few visits to habitat need to be made with this in mind. Several observations, however, have remained consistent with every visit. The first, and most obvious, is that populations are degrading with more and more dead and dying plants each year. This degradation is most obvious along the edges of the populations where plants are most stressed. The second is that there has been no reproduction via seed over at least the last ten years. Growth via offsets has also been virtually unnoticeable. Combining both of these observations gives us a sad result; many copiapoa species are destined for extinction if trends continue. In particular, *C. solaris*, *C. ahremephiana* and *C. decorticans*, are already speeding in this direction. One conclusion is obvious; if you are planning a visit to see plants in habitat, do it as soon as practical to avoid disappointment.

▼ *C. longistaminea*, growing about 4 km south of Cifuncho near the coast.



Copiapoa distribution

Copiapoas only grow in a small area of Chile, mostly along the immediate coast. The distribution extends only to about 32°S, below which the increased winter rainfall allows for a dense grass or shrub layer (photo right). In the far north, as well as away from the coast, the conditions are so dry that no cactus can survive (photo middle right). Further inland and with an elevation of over 3,000 m, vegetation again becomes possible however the cold nights with frequent frosts only allow hardy shrubs and cactus, such as oreocereus to survive (photo below). Going further inland near the boundary with Argentina and Bolivia, the vegetation changes as the elevation increases so that above 4500 m it is strictly perennial grasses, above 5500 m there are no plants.

The map on the following page shows the approximate distribution of the genus *Copiapoa*. Note that the map only shows approximately 30% of the total N-S extent of Chile.



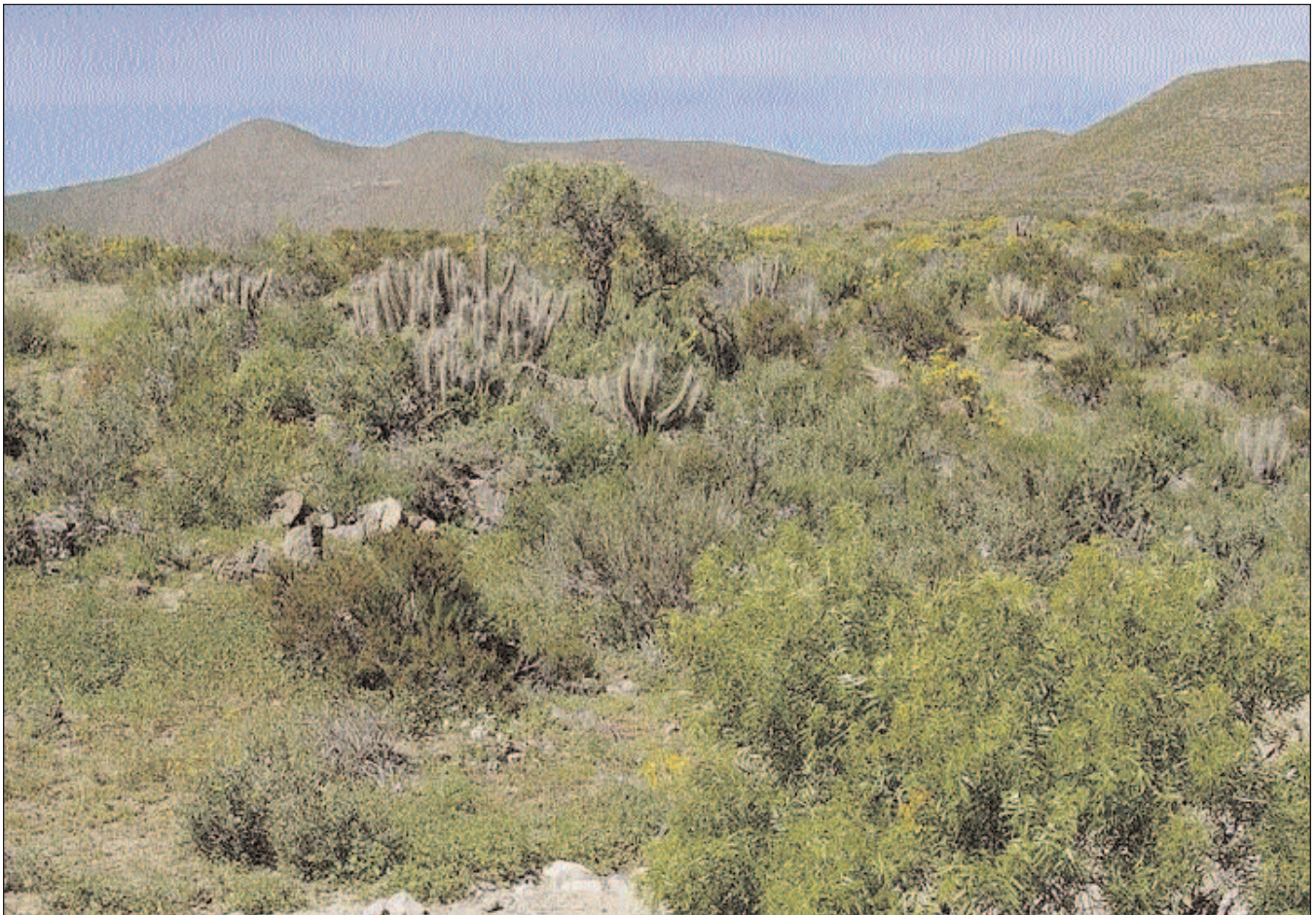
To write
Intro, The genus *Copiapoa*

The flowering desert: after a wet winter

The chances of a once in a lifetime trip to the copiapoa environment coinciding with a 'flowering desert' event is minimal. On the average, only one winter in five has any significant floral display. Then, it is usually only the months of September and October that are spectacular. By November, much of the growth has dried off and is going to seed. Some winters, there are isolated rain events which are enough to bring the desert to bloom, as it was in 2005. Most wet winters, such as 1997 and 2002, correspond with an El Niño event. Unlike other continents, where the El Niño event gives rise to drought conditions, the west coast of the Americas experiences heavy rain.

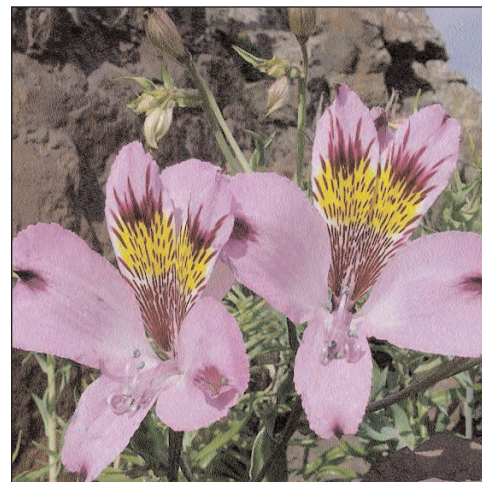
Although not as wet as the previous El Niño of 1997, the 2002 year there had several significant rain events which affected copiapoa habitats in the north. This turned the otherwise dry area into a 'flowering desert'. The first rains fell during June and the last rain was in August. Not all parts of the copiapoa habitat received useful rains

▼ No copiapoa here! South of Vallanar most of the coastal hills are totally covered by leafy shrubs and herbage during wet years. While *Eulychnia acida* can survive, globular cactus would be smothered for months by the fleshy leafy foliage. During dry normal years, this scene would look very arid, with only the perennials being in partial leaf during winter.



with the area between Pan de Azucar and Caldera missing out on most of the rain. Other areas, such as near Botija, received at least three separate rainfalls. Taltal received 20 mm during one evening. This caused widespread but minor flooding along the coast road to the north. The winter of 2005 was also unusually wet north from Taltal with the spring bring a significant rain to the Vallanar to Caldera sectors. The photographs in this chapter show some of the plants seen during these periods.

During the average year, the southern areas (south of Vallanar) received much more rain than the north. Here, the desert blooms more often in the real sense of the word, with the otherwise bare ground being carpeted by non-succulent plants. The places with the best flowering are usually heavily overgrazed and the flowers are



▲ *Alstroemeria* species are common plants in many copiapoa habitats. During very dry years, they remain totally dormant. During years with some rainfall they produce short stems with a few leaves. During wet years they put on a spectacular display, with abundant flowers on leafy stems up to 1 m long.



◀ The area north of Taltal received several rain events during 2002 which resulted in abundant annual growth. Here, the perennial *Alstroemeria* ??(purple flowers), *Cleome* (white flowers) and a number of other annuals grow among *Copiapoa cinerea* 'Albispina'. This photograph shows very lush growth, most annuals among copiapoa looked more like the photo shown on page ??.



- ▲ This very common small growing blue flowering bulb often forms swards of light blue on rubble covered slopes about six weeks after rain. It often grows together with a white and yellow bulb seen behind.
- ▶▶ *Oxalis gigantea* is a common shrub of the fog zone. Usually completely leafless, it is here in full leaf and flowering. Climbing over the foliage is a *Cuscuta* species, a parasitic vine.
- ▼ A lily amongst the spines of *Eulychnia breviflora*. This species appears to be very rare and this may be because it is palatable and can only thrive in among the protection offered by spiny cactus.



quick growing and flowering annuals such as *Calandrinia* spp. Bulbs and vines however, form a conspicuous and abundant component in the shrub covered or rocky areas. In a good year, the area south of Vallanar will have most of hillsides, especially those that receive maximum shade (the south sides of steep hills) completely covered in green. During such flowering desert situations, it becomes obvious why copiapoas are very restricted in the south to rocky, north facing slopes: all the other habitats are covered with rank, damp foliage that would envelop and smother copiapoas. It was only on the rocky, sunny north facing slopes that the ground is not covered by dense herbage, allowing the cactus to survive.

In the north, the growth of annuals, vines and bulbs was much less than in the south. Even on the most favorable south facing slopes



the growth was patchy and seldom covered all of the ground. Areas of annual growth and areas of high concentrations of copiapos occupied separate microhabitats. Usually, the rockiest slopes had copiapos while the gravelly or gentle slopes had higher numbers of annuals, vines and bulbs. Photo ?? illustrates this point well. Here, areas supporting *C. 'albispina'* have few annuals and the areas without copiapos have much higher concentrations of annuals. I would assume that during an exceptional El Nino year the rainfall would be much higher and the growth of the annuals would be at levels similar to the south (see photo, page ??).

Copiapos responded to the rain by quickly plumping up their stems. But this was only evident on plants which were still in good condition. Very stressed plants appeared not to respond to the rain



▲ *Euphorbia copiapina* from Tigrillo. The plant above is going dormant and has most of its fruits already 'popped'. The plant below is younger.



◀◀ *Euphorbia copiapina* with its caudex exposed. The ruler divisions are 10mm. The extent of the foliage growth is determined by how much rain has fallen. At this location, the sand was only slightly damp and the plants were already going dormant. If it had rained more, they may have ten times more foliage.



▲ *Dioscorea* sp. foliage and flowers.
Insert: Two fruits which are just about ripe. By the time the fruits are ripe the leaves have been shed from the stem.

▼ *Dioscorea* sp. Each thin stem arising from the caudex is one season's, but not necessarily one year's, growth. This caudex is larger than the average.

and I assume these were beyond recovery, most likely because the roots were no longer functioning. Most copiapoas (the exceptions are *C. echinoides* and *C. megarhiza*) do not flower shortly after rain events. Instead, they put their energy into new growth, leaving flowering until the season again becomes dry.

Several caudiciform euphorbias are native to the copiapoa environment. The best known is *Euphorbia copiapina* which grows in sandy, coastal soils between La Serena and Tigrillo. Two other species, *E. thinophila* and *E. porphyrantha* grow in the study area. During dry years the caudex remains leafless, only sending up the non-succulent foliage once enough rain has fallen. Typically, the top of the caudex is about 100 mm under the sand's surface, from which several, thin shoots arise. The caudiciform euphorbias can form dense populations, sometimes reaching densities of 10/m². During 2003, which had absolutely no winter rain in many areas, some *Euphorbia copiapina* sent up weak stems during mid winter. The growth of many of the leafy plants in the northern copiapoa habitats is not seasonal. Rather, it is ephemeral, that is, the plants respond to rain only rather than the seasons when beginning their growth. Some, like *Euphorbia copiapina*, can grow in response to both season and rainfall. If the previous season was wet, then next year plants will send up stems through completely dry soil. If the previous year was dry, plants remain fully dormant until awakened by damp soil.

In many areas, we found populations of *Dioscorea* sp. growing in the same habitat as the caudiciform *Euphorbia*. The caudex is buried about 75-100 mm under the surface of the sandy soil. After a rain it





produces a thin, short lived stem with simple leaves. Plants often grow in dense numbers but are impossible to detect during normal dry years. A related species with different leaves was found in the far north near the Botija valley. We have visited this area on a number of occasions and have never found dioscoreas in leaf, suggesting that the caudex can survive several years without coming into growth.



▲ This member of the sunflower family can be a common annual north of Taltal during wet years.

▣ Shrubs that grow within the fog zone come into full leaf and flower during wet years. On the right is a *Euphorbia lactiflua* in full bloom. This plant leafs out and flowers quickly after a rain event and can produce ripe seeds within four weeks.

▼ Copiapoas in northern areas are seldom found in areas which support heavy annual growth. Here, annual growth is in an area devoid of copiapoas while in the area with copiapoas the annuals are stunted, small and less dense than on the left.





Nolanas are the most common plant seen shortly after good winter rains. The perennial species (about ???) rapidly fully leaf out and the annual species, of which the three pictured are the most commonly seen, flower within five weeks of rain. The genus ????????????

▲ *Nolana mollis* forms mounds to over 1 m in diameter and responds quickly to rain. Its leaves are often wet from the absorption of water from the atmosphere. The leaves are very salty.

► An annual nolana which mainly grows along C.
▼ *haseltoniana* along the coast between Taltal and Paposo.





- ▲ A perennial species which dies back to the root-
- ◄ stock during dry periods (note dry stems from previous years).



- ◄◄ *Nolana paradoxa*, growing here with *C. cinerea*. Single plants can grow to one meter in diameter within a few weeks. This species has been brought into cultivation, mainly in the UK.
- ▼ *Nolana aplocaryoides* is the most common nolana in many of the drier areas north of Taltal. It flowers later than *N. paradoxa* (left) and is also usually found on more rocky and open ground.



- *Calandrinia* is a common perennial leaf succulent which only grows during wet years. At least four species are commonly seen after wet winters.



- A caudiciform *Oxalis* species found growing on Mt. Perales. Such plants can survive for years without producing leaves.





◀◀ This shrub, which can grow to almost a meter in
 ▲ diameter and half as high, flowers quickly and is
 finished before many of the slower flowering
 plants, such as bulbs, begin.
 (east of Taltal, August, 2005)



◀◀ *Euphorbia lactiflua* flowers just about every year
 ▼ with a few flowers. With good rain (as in this pic-
 ture, north of Paposo, 2005, the flowering bracts
 are two to three times as large as during a dry year.



► This *Caesalpinia* shrub grows to 1 m and is normally leafless. Flowering begins about 4 weeks after a rain event.
(Q. Canas, August, 2005)

✚ One of the first bulbs to flower is this species with leaves which can reach 1 m in length. All within 5 weeks. Even during a wet spring, most leafed out bulbs do not produce a flower
(Q. Canas, August, 2005)

✚ A number of *alstroemerias* are very common, especially on rocky rubble slopes or roughly sorted alluvial deposits. this one was doing its best to smother the *C. haseltoniana*.
(Q. Canas, August, 2005)



► This member of the poppy family flowers quickly. the flowers only seem to last one day with the petals falling quickly. Normally, it is an almost leafless shrub to 1 m.
(east of Taltal, Aug., 2005)





◀ View of the true desert inland from Paposo at 1300 m elevation. Even during the wet year of 2002 this area was completely bare of plants of any kind. The abundant guanaco trails suggest that this area was at times a well vegetated grazing area. Today, even when rain falls, there are no longer any viable seeds in the soil, with the exception of a few ephemerals which grow in the gullies and places where water flows.



◀ The aftermath of rain on bare hillsides. The 'river' bed in the Qebrada Botija with new sediment. The lighter colored sand, gravel and rock has come down from the hillside during the wet El Nino year of 1997. The hillsides in this area are now so devoid of plant cover (mainly *Deuterocohnia chrysantha*) that any substantial rain causes serious erosion.



◀ Copiapoas can benefit from only a few millimeters of rain. By having roots just under the surface this *Copiapoa cinerea* can access a large area of damp soil. *C. cinerea* ssp. *columna-alba* can have near surface roots which extend over 8 m from the plant. A rain event of as little as 2 mm will moisten the soil to a depth of about 50 mm, providing plants with useful amounts of water. Plants also have a deep taproot which can access water from the rare soaking rains.

Then and now

One of the goals with our research for '*Copiapoa and their Environment*' (1996) was to photograph a selection of plants and habitat scenes at locations which could be rephotographed in later years. In this chapter we are presenting 'before and after' scenes from some of these locations.

Copiapoa solaris 1972 and 2003

The photographs on this and the facing page show the most dramatic change of any of the photographic pairs. The scene below was taken by Pablo Weisser in 1972 when he was part of a team doing a study (Weisser & Laubscher 1993) on the biomass of a *C. solaris* population. The photograph on the right shows the same location some thirty-one years later. It can be clearly seen that all but the smallest two *Copiapoa solaris* in the foreground have died. Other noticeable changes include the death and decomposition of two *Eulychnia* in the background (right, mid-distance). We have always suspected that the *C. solaris* population at El Cobre is in a rapid state of decline but have not had evidence to back this up. This picture provides clear proof.

The implications of this data are bleak for lovers of copiapoa habitat. Assuming that trends continue (and there is no suggestion that they will not) then it will only be a few generations before many of the more stressed species will be at or near extinction. The copiapoa at El. Cobre certainly are!

▼ Photograph (monochrome print), taken in 1972. From the lack of shadows, it appears that the day was foggy.



We invite readers who may visit Chile to document changes that occur at this easy to reach site. El Cobre lies further down the valley along the visible road on the right. At the bend in the road a track leads up a valley to the left (south). This eventually leads to another *C. solaris* site (the Norma site of *Copiapoa* 1996), which was part of our health comparisons survey (see page 143, *Copiapoa* 1996).

Today, travellers along the El Cobre to Antofagasta road still see many large cactus clumps as they drive up into the mountains. Few realize that the great majority are dead with most of the others on their way. The habitat in general seems not to have changed much in the thirty years. It appears as a very arid desert and has always appeared so. No herbaceous or woody plants were evident in 1972 however the valley appears to have had many large *Nolina* clumps.

Photograph (transparency), taken on a sunny day, June 2003 (28 mm lens). The GPS location is 24°17'51.1"S 70°30'26.1"W, elevation 680 m.





This photograph was taken at about 9:15 in the morning on a sunny day. The camera is looking south-southwest.

▲ ▼ Ritter's *C. columna-alba* habitat photograph, 1968(?) and 2005

This photograph appears in Ritter (1980, page 1215). It is unknown when it was taken but it would most likely have been in the late 1960s during one of Ritter's later field trips. The large eulychnia on the right has died and is only a heap of broken stems (yellow arrow). Remarkably, the eulychnia in the centre seems to be little changed. The *C. columna-alba* population has thinned out, with many of the larger plants having died. Growth is evident but only marginally, with some offsets having enlarged by perhaps 10%. Note how the shrub (white arrow) is almost identical.

Photographed, May, 1994.





▣ ▾ *C. cinerea* 'Albispina', 1994 and 2005

The original photo, taken at dusk using a flash, shows two plants growing from rock crevices. During 2002 road works, the leftmost stem was knocked off. The right stem has since twisted somewhat. Growth is difficult to assess but it appears to be negligible. The plants appear to be losing condition, as indicated by the slight decrease in white wax near the apex, which seems to be flaking off to reveal the tan coloured bark underneath. The bark, often stained blackish by algae on plants growing further inland, is here free from algae because the plants are so near to the salt spray from the shore.

This location is easy to find, being only about 70 m from the intersection of the Esmeralda valley and the Pan de Azucar road (275 m).
GPS= 25°54'41.0"S 70°37'33.1"W



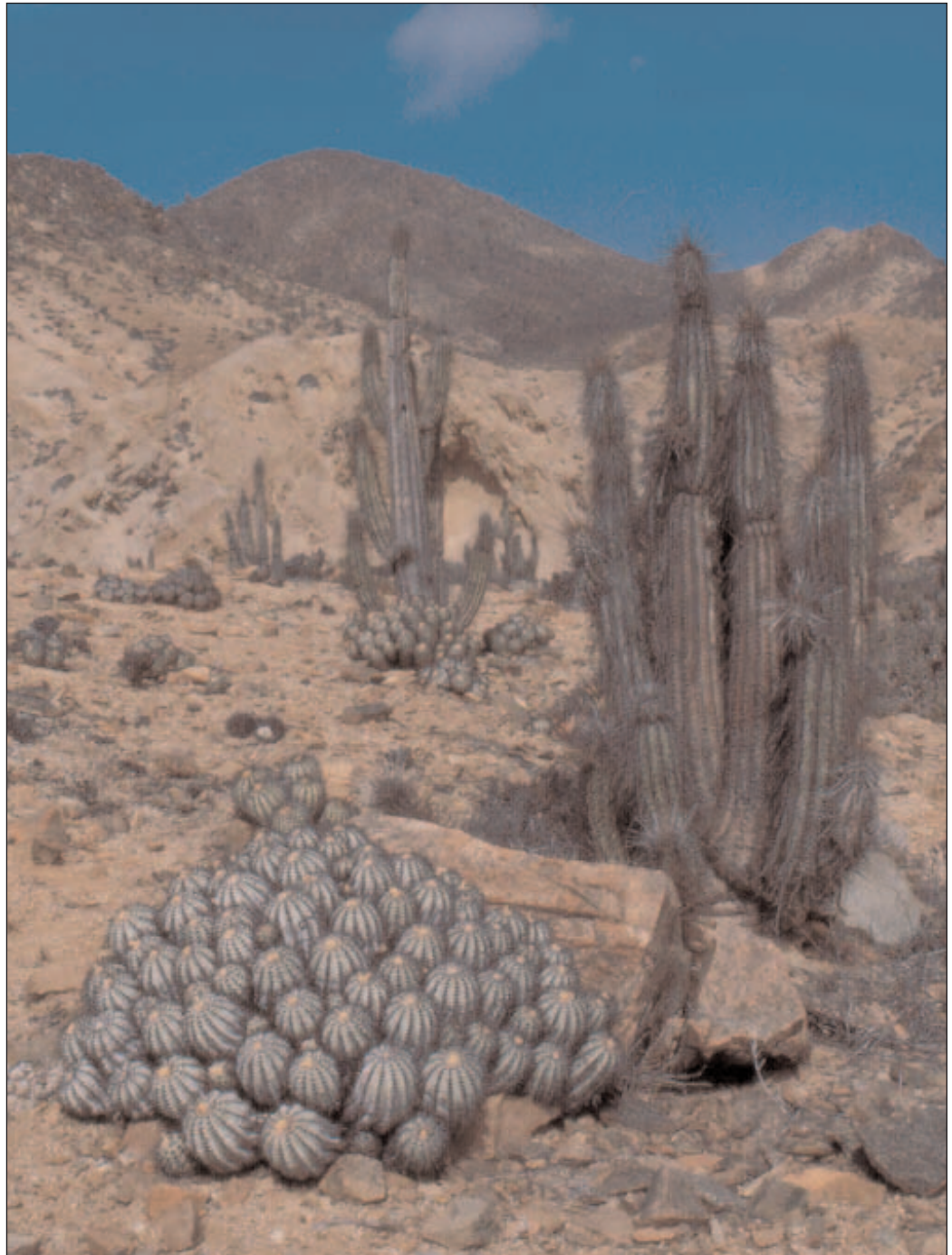
Photographed September, 2005. Plants are growing just west of the coastal road on a rocky outcrop. The plants face north.
GPS= 25°20'07.5"S 70°26'47.6"W

Copiapoa longistaminea 1996 and 2005

The middle reaches of the Guanillos valley are one of the richest habitats for copiapos. In this vicinity four species grow together. *C. longistaminea* is the most frequently seen species but also present are *C. grandiflora*, *C. laui* and *C. sp.* 'Guanillos'. The large *Eulychnia saint-pieana* are healthier here than anywhere else.

This location is about 50 m north of the Guanillos valley road (hidden in the mid-distance). The photograph is looking south at (25° 53'S 70°39'W).

Photographed in 1996 as a transparency. The photograph first appeared in *Copiapoa* 1996 page 93 where it was presented in mirror image.



The red arrow indicates one of the several new offsets which have developed over the time span. Several of the other smaller stems seem to have enlarged however none of the larger stems appear to have grown in size or length. Note the white arrow which indicates the location of a dead *C. grandiflora* clump. The same clump is evident in the 1996 photograph and appears to be unchanged over eight years. The *Eulychnia saint-piena* in the foreground has grown some stems. Note the yellow arrow which shows the stem with the greatest enlargement.



Photographed in 2005
as a digital image.

Copiapoa cinerea ssp. *columna-alba* 1994 and 2004

I first took this photograph in May of 1994 at 26° 08'17"S 70°37'45"W, never realizing that I would return numerous times to revisit this location. At the time, the large single headed plant with its distinctive lean appealed to me and when I returned in 1996 the plant was still there and apparently healthy. The heavy rains during the autumn and winter of 1997 seem to have caused a number of plants to die, including this one. Instead of drying slowly and hollowing out from the inside as many plants do when they die during drought, this plant rotted and left only a row of spines and some waxy epidermal material to indicate its position (just visible on the 2004 photograph). During the 2003-2004 period the plant on the lower right disappeared. Since no spines or dried material remain I must conclude that it was dug up by a collector. One large rock has been upended and several others appear out of position. The mid-distance appears not to have any changes in plant numbers however it is the smaller plants that tend to be dug by collectors.

Over the years I have examined the gravel for young seedlings. During 2001 a few were found, apparently from the previous year which was wetter than normal. No seedlings were found in subsequent years, indication that *C. cinerea* ssp. *columna-alba* has not pro-

C. columna alba, first photographed as a transparency in 1994 (see page 85, *Copiapoa* 1996). Plants grow on a small raised alluvial flat about 30 m south of the Pan de Azucar road.



duced any seedlings which have survived over the last ten years. In 2004 an area of at least 15 m² was combed for seedlings. The surface gravel was carefully removed to a depth of about 10 mm. Twelve seedlings of *Eriosyce esmeraldana* were found, the smallest being only 5 mm (estimated to be 2-3 years old). Such young plants grow under the translucent granitic gravel for a number of years. The lack of copiapoa seedlings in this suitable habitat indicates that *Eriosyce* are able to reproduce and survive under more arid conditions than *C. cinerea* ssp. *columna-alba*. Looking for seedlings at this location will be an ongoing project and I hope one year to be surprised by abundant and healthy copiapoa seedlings which are large enough to survive the inevitable dry years ahead.

September, 2004. A digital photograph.



Copiapoa dealbata 1994 and 2004

During 1994 we visited (at 28°07'11"S 71°06'02"W) *C. dealbata* for the first time and wandered around for several hours among a large population a few kilometers inland from Carrizal Bajo. The condition during that year was quite dry but the plants were turgid. We noted signs of goat grazing as well as guanaco. During late August of 2004 the area had experienced some rain and the annuals were growing though not yet flowering. In general terms and with only a casual glance at both photographs it appears that not much has changed. A more careful examination does however, show growth.

May 1994. Andrew Thompson and Attila Kapitany admiring *C. dealbata*. From a transparency.



The *C. dealbata* in the foreground both appear to have a few new offsets. The plant on the lower right shows one small new offset while a number of others appear to have grown larger. None of the large stems appear changed. The plant on the left has more growth with all of the small offsets from 1994 appearing to have grown larger. Most of the plants in the mid-distance also have 'new' small offsets. The size difference in the clumps between photographs is due to differing camera focal lengths.

Assuming that growth is consistent over decades, how old are the larger clumps? Note the dead clump (mid-distance, right) which appears unchanged after ten years.



August, 2004. Ingrid Schaub and Ricardo Keim admiring *C. dealbata*. A digital image.

Copiapoa haseltoniana 1996 and 2005

The *C. haseltoniana* population (at 24° 09'S) pictured on this page has been visited and monitored from 1996 to 2005. We photographed the site in 1996 and included a picture on page 97 of *Copiapoa* 1996. During dry years it looked as pictured below.

The copiapos have changed only marginally, showing offsetting during 1997 and 2001 in response to the rain. After nine years, growth is noticable on the central foreground plant which has grown a new offset. In 2005 it was noted that many of the earlier offsets produced after the good rains of 1997 had aborted. We suspect that the dry years of 1998-2001 prevented the plant from supporting the new growth. Plants in the most favorable conditions, that is, those growing in small rivulets where rainwater would briefly flow and infiltrate, show the plumpest stems and have the healthiest offsets. No young seedlings have ever been found older than one year or younger than several decades. Most of the larger stems have grown somewhat, as shown by the progression down the side of two black scars on the largest plant (red arrow)

May, 1996 photograph (print) of the 24° 09' population of *C. haseltoniana* growing along the coastal plain north of Taltal.



Most color variations are due to the different photographic media however the colour of the apex wool is decidedly less orange in the 2005 photograph. We have no explanation for this phenomenon. The lower stems are noticeably less black during 2005. Most likely this is due to less fog and rain which would have inhibited the algae which gives the bark its distinctive dark colour. Two species of annual *Nolana* reflect good winter rains. The conditions during September of 2005 were the best the author has seen for wildflowers in the area between Taltal and Papos. This dramatic change between the degree of annual growth seen in these two photographs points out the difficulties in making conclusions based on a single, or even a dozen visits over time. A visit of a month is but a snapshot in time from which few firm conclusions should be made about the environment. Those that are made, can later be proved to be unfounded, as conditions change. Had I only visited this area once, be it in either in May 1996, or September 2005, I would have quite different impressions of the environment in which copiapoas grow.

September, 2005 photograph (digital).



Copiapoas: south of Huasco

Copiapoa coquimbana

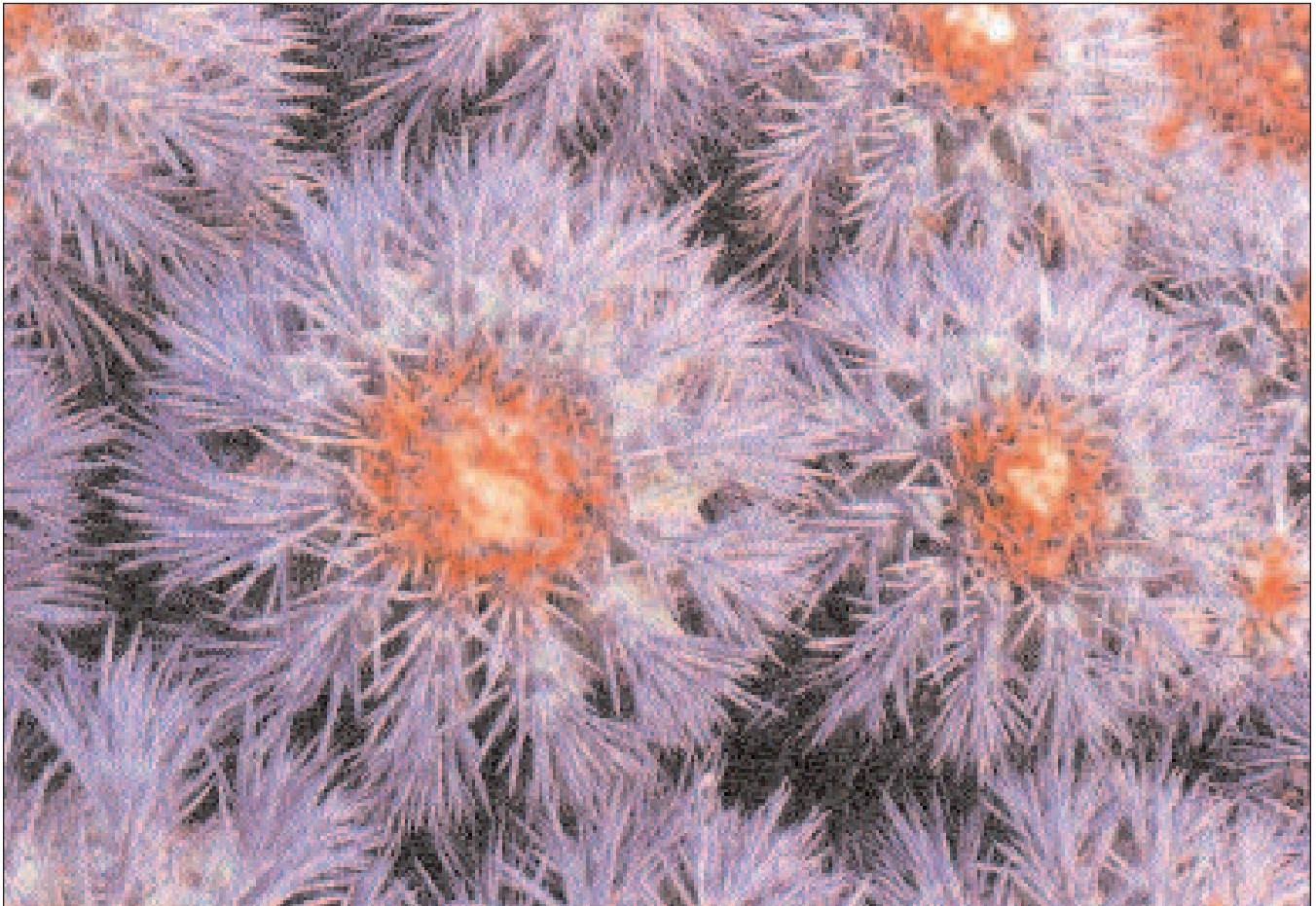
Copiapoa coquimbana 'Domekoensis'

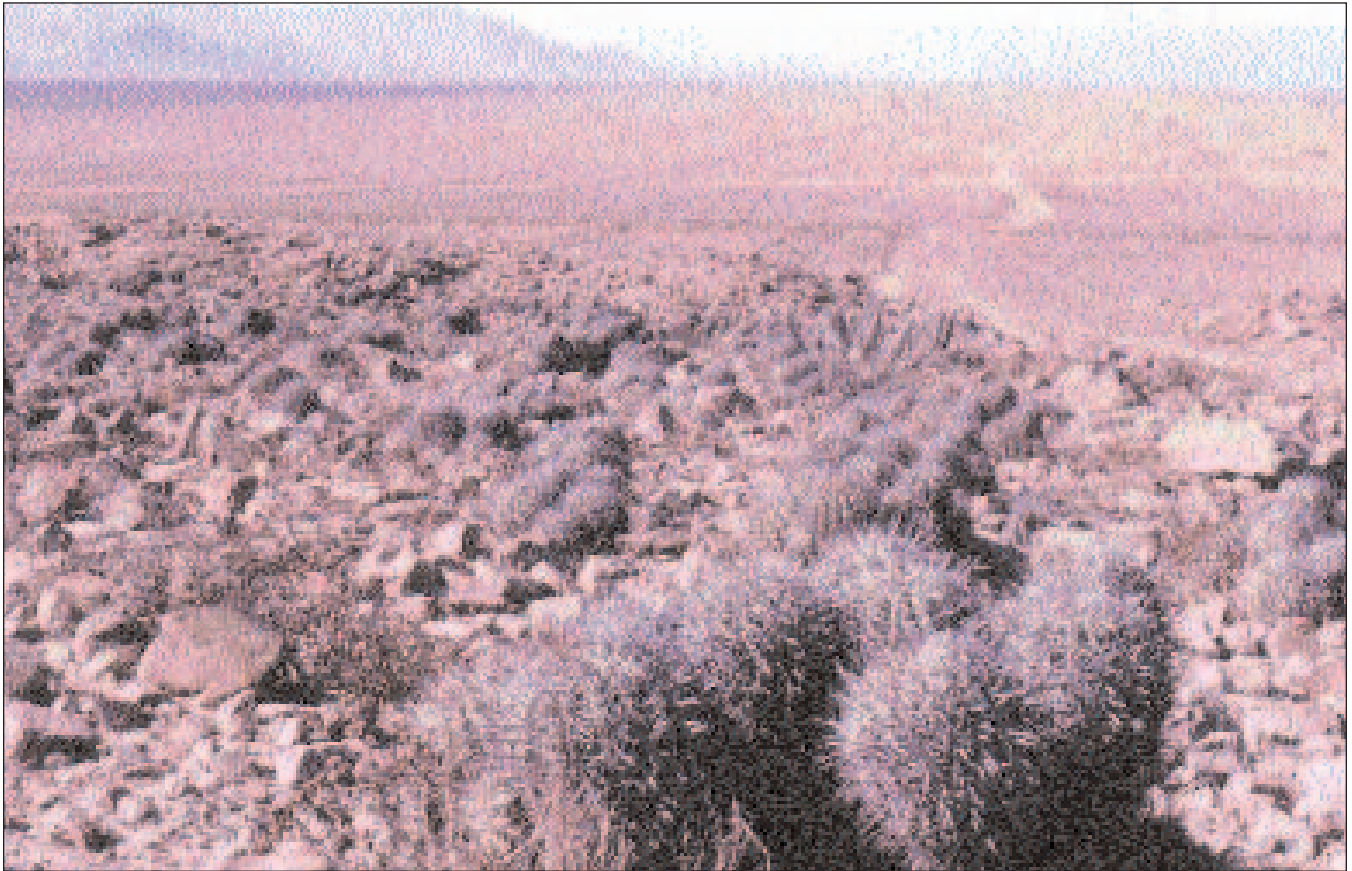
Copiapoa humilis ssp. *australis*

South of Huasco

The sector south of Huasco encompasses the full distribution range of the most widespread and abundant species, *C. coquimbana*. It extends to as far south as the mouth of the Rio Choapa (31°40'S), which runs into the sea 35 km north of Los Vilos (a distribution of 490 km from north to south). The topography of the coastal mountains within this area is not as uniform as further north. There are many valleys which dissect the coastal hills, which seldom reach over 700 m, except for the area just south of Huasco. In the far south, there are only low hills or coastal plains near the immediate coast. Along the coast north of La Serena, there are wide, flat plains which in places are covered by sand dunes. Because of the sand dunes and many river valleys, there is no coastal road between La Serena and Huasco. Instead, the Pan-American highway goes inland through quite dry and high elevated mountains (with passes reaching 1100 m). Within this inland area there are a few dry river valleys which allow the fog to penetrate and provide suitable habitat for *C. coquimbana*.

▼ *C. coquimbana*. This population had unusually golden-brown colored new spines. This population, from north of Maitencillo, shows strong *E. echinoides* tendencies.





▲ *C. coquimbana* growing on the very old alluvial deposits above the Huasco Valley, seen in on the far left.⁽¹⁾ The area in the background was completely cleared for agricultural development many years ago but it has since been abandoned and is now only used for goat grazing. *C. coquimbana* is still present in the area, especially on the visible windrows, most likely from root regrowth.

◀◀ *C. coquimbana*, growing above the Huasco valley.



▲ Looking down into the Huasco valley from the south. The dense vegetation in the foreground restricts copiapos to the rocky outcrops.

» Inland from Trapiche. Goats are grazed in many of the habitats where *C. coquimbana* grow. In the short term, they indirectly aid the survival of mature *C. coquimbana* by eating competing grasses and shrubs. Over time, their hooves damage the soil, cause erosion and ultimately prevent most slow growing perennial plants, such as cactus, from successfully regenerating.

The environment south of Huasco gradually becomes more vegetated. The area usually receives several winter rains every year, and while they may only be a few millimeters, it is enough to support continuous vegetation on the exposed coastal hills. The cooler temperatures, especially during spring and autumn, reduce transpiration and this also helps leafy plants survive. Near the coast from La Serena south, the coastal vegetation is very well developed, restricting copiapos to the steeper, north facing rocky slopes. Further inland, especially where larger hills provide a rain shadow from the winter rain clouds coming from the southwest, the hillsides are covered by less vegetation, allowing copiapos to become abundant, however here it can also become very cold during winter so frosts become a limiting factor on the flatter habitats.

Only a few forms of *C. coquimbana* have been impacted by man's activities. Agriculture has changed the landscape in the Elquí and Huasco valleys. Since the construction of irrigation dams in the upper valleys, some of the flatter slopes formerly covered in copiapos have been transformed into irrigated fields. Urban expansion in La Serena has impacted in a small way on some populations. Large scale mining is restricted to the higher elevations above the copiapoa distribution. Goat grazing is common throughout the area where settlements occur and permanent water is available.



Copiapoa distribution

The area between Coquimbo and Vallanar is the main population center for *C. coquimbana*. Here, it can grow as far as 70 km inland as well as right down to the coastal rocks, but not in a continuous band. The great majority of the area (perhaps 90%), especially those areas which have soil and gentle slopes, are shrub covered and have no copiapos. This applies to almost all of the south facing slopes, especially near the coast. Dry stream and river beds and their older rocky alluvial terraces are the most visible (and easiest to visit) habitat for *C. coquimbana*. Here, a lack of soil coupled with very good drainage inhibits other plants which would compete for both light and water, allowing copiapos to survive. The largest contiguous areas occupied by *C. coquimbana* are the Huasco and Elquí valleys where plants grow on the rocky north facing valley slopes all the way inland to Vicuña. Other areas occupied by the species are coastal rocky outcrops and rocky hills, which are not too covered by other vegetation. The more inland populations (where rainfall is less) are often growing above 1000 m on dry, rocky, north facing hillsides.

C. coquimbana 'Domeykoensis' grows from 15-25 km west of the town of Domeyko, where it is found at 400-850 m in elevation, mainly on rocky north facing slopes.

C. humilis ssp. *australis* has only been found near the top of one small hill near Huasco.

Huasco
Maitencillo
Freirina
Elquí valley
Vallanar
Huasco valley
Cariziallillo valley
Vicuña
La Serena
Choros Valley
Domeyko
Coquimbo
Sarco
Chequeque
Trapiche
Quebrada La Honda
Los Vilos
Rio Choapa
Pan-American highway



▲ A single headed plant from the south side of the Huasco Valley near Maitencillo. The presence of a taproot is not a consistent characteristic in all *C. coquimbana* populations.⁽²⁾

▲ *C. coquimbana* near the road south from Freirina during the wet winter of 2002. It is unusual for copiapos to grow so close to 'other plants'.

▼ *C. coquimbana* from near Maitencillo with new off-sets. These developed after the wet winter of 2002. Most have since been shed during the following dry

C. coquimbana

This species is, throughout its distribution range, very difficult to typify, being variable in almost all traits. Plants can be low and clump forming or have erect stems. They can be very spiny and gray or be dark green with short spines and wider stems. The spines can be straight, or curved, thick or thin. The ribs can be straight or rippled, the body can be dark green, olive or light. As for a body colour, the only thing that can be said is that no forms have a white wax covering. All of this variation applies for plants between populations as well as plants within populations. It appears that the northernmost populations are the most variable and many populations have freely hybridized with *C. echinoides*, creating a hybrid swarm of mind-numbing complexity. The most diverse of such habitats is north of Huasco in the lower Carizallillo Valley, where the degree of intermixing of characteristics is enlightening for anyone who may think that copiapos can be easily 'sorted out'.

C. coquimbana is often thought of as being a coastal species which extends inland into the Elquí and Huasco valleys. The Huasco River Valley is usually considered as the northern limit of distribution for *C. coquimbana*, however this is not true. Along the coast, it extends to about 20 km north of Huasco, inland, it extends north to at least Chequeque, some 25 km northwest of Vallenar. Here, it is also a mountain species, only growing over 1100 m in elevation. In the extreme south, it grows to within 40 km of Los Vilos.⁽³⁾

The Vallenar valley is home to several populations which were given species or varietal status by Ritter (1980). *C. vallenarensis* is a spiny form from near Vallenar and when stressed, shows a degree of





consistency. *C. alticostata* (see page ???) is recorded from north of the agricultural settlement of Maitencillo, some 15 k west of Vallenar. It has erect stems with a less spiny armor than typical *C. coquimbana*, but from my view, it is only a transitional form between this species and *C. echinoides*, typical examples of which grows less than 10 k north of Maitencillo.

Ritter described several taxa to try and clarify the diversity of forms of *C. coquimbana*.⁽⁴⁾ His *C. pseudocoquimbana*, which he delineated via a geographic distribution, grows in the long and wide Choros valley. Plants here are relatively uniform, however in other nearby populations they are not.



▲ Plants growing inland, such as this one from near Vicuña in the Elquí valley, have spines which are thicker and more curved than coastal plants. This plant was growing at 620 m in elevation.

▣ *C. coquimbana* on the north side of the Huasco Valley, growing on coarse alluvial rubble.



◀◀ Two examples of extreme variation within the species. These plants grow in the Huasco Valley, south of Freirina. The small, spiny plant on the right could, at first glance, be mistaken for another species.



▲ This plant, growing in the upper Quebrada La Honda, has long spines and resembles some *C. rupestris* in growth habitat.

▼ Looking south across the Elquí valley towards La Serena. *C. coquimbana* extends along the valley sides to as far inland Vicuña.

► Within most populations, there are extreme variations. Here, a tall, dark bodied plant grows with a light colored, compact one. The other plants within this population were transitional between these two extreme forms.

▼ *C. coquimbana* 'Pendulina', a Ritter name for the form growing along the coastal cliffs south of the city of Coquimbo. When on shady cliffs, plants are pendulous, when growing in the open (below), they are similar to many 'typical' *C. coquimbana*. The red material on the spines is a lichen which favors misty situations.





▲ *C. coquimbana* near Sarco. Some plants grow among the stranded beach rocks which have been elevated above the high tide zone by the rapidly uplifting continental plate.⁽⁵⁾ These plants have relatively thin spines when compared to inland populations.

▣ *C. coquimbana*, growing about 15 km inland from Sarco. This population lies to the west of *C. coquimbana* 'Domeykoensis'. The plant was growing among a large *Eulychnia acida*.



▼ *C. coquimbana* from near Maitencillo in the Huasco valley. The population grows on the elevated river alluvials. This form has been called *C. 'Alticostata'*

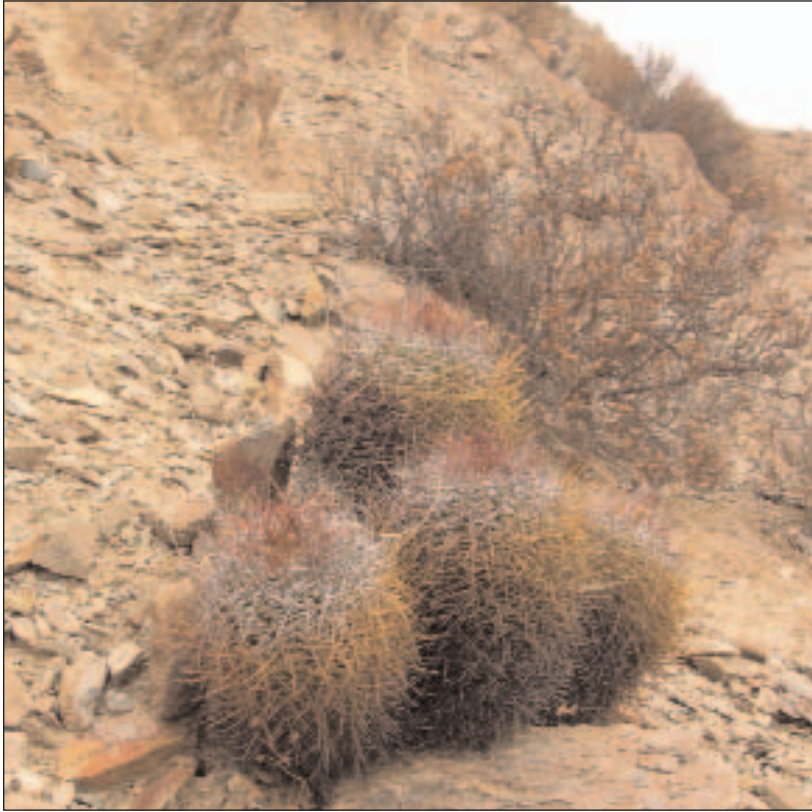


►► *C. coquimbana* from 10 km northeast of Huasco in the Carrizallillo valley. This population is the northernmost coastal extent of *C. coquimbana*. Early spring flowering with multiple buds breaking open nearly at the same time is a characteristic of this, as well as *E. echinoides* and *C. megarhiza*.



▼ *C. coquimbana* from just west of Vicuña. This population is 60 km from the coast, growing on the slopes of the upper Elquí valley.





“ C. coquimbana from Chequeque⁽⁶⁾. These plants
 ▲ grow far inland and well above the fog layer, hence
 the clean, unstained spines.

▼ A large plant of C. coquimbana from a north facing
 hillside just west of Chequeque. This plant was
 growing at 1250 m.



► A very small form of *C. coquimbana* from 20 km south of Huasco. It was growing in cracks in shale which may account for its small size, especially when compared to larger, more typical *C. coquimbana* growing in soil nearby. This plant resembles the coastal *C. coquimbana* 'Fiedleriana', which is said to grow only in the vicinity of Huasco.



▼ *C. coquimbana* inland from Sarco. This form has distinct areoles. Compare this to *C. coquimbana* 'Fiedleriana' (pages ???-???)





▲ *C. coquimbana* (right) from near Sarco compared to *C. coquimbana* 'Fiedleriana' (left) from Huasco. To me, the only obvious difference is a slightly more pronounced chin below the areole.

▼ An unusual *C. coquimbana* growing in very poor soil on a rocky ridge. Unlike this partly buried plant, most nearby plants were single headed and stood well above the ground.

◀◀ *C. coquimbana* growing on a gravelly plain. Note how the less rocky and more sandy area in the mid-distance is heavily covered with shrubs.



▲ Mature specimen showing new spines and well developed apical wool. The ribs are deep and the spines regular. The grayish colored older spines indicate that plants are subjected to regular fog.

▼ Habitat for the core area of *C. coquimbana* 'Domeykoensis'. Many of the plants are several times taller than they are wide.



C. coquimbana 'Domeykoensis'

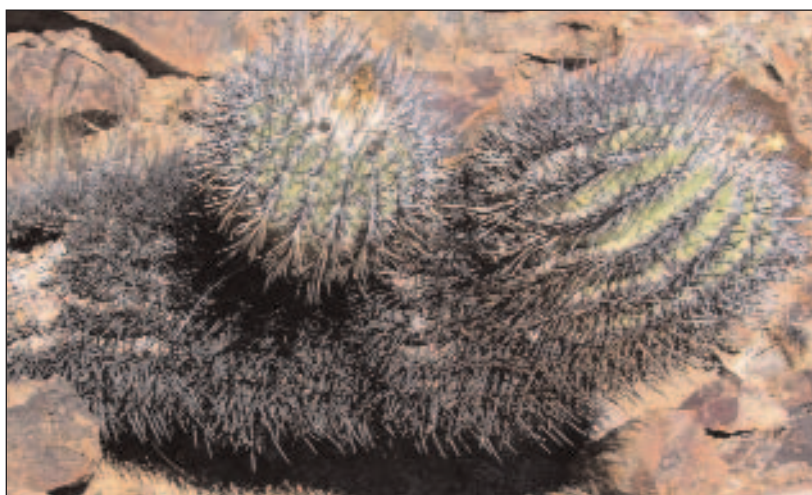
C. coquimbana 'Domeykoensis' is the most unique of the various forms of the species. While the inland populations (growing near the road to the coast) of *C. coquimbana* 'Domeykoensis' have been well known for many years, the core population, tucked into a side valley nearer the sea, has apparently never been commented on. The core population was first discovered in 2004 by Ricardo Keim and Ingrid Schaub. The healthiest and most variable plants grow between 500 and 650 m in a west facing, steep sided valley which acts like a funnel to concentrate the fog and mists, which are heaviest at this elevation. Another plant-friendly feature of the valley is its quartzite rock, a very hard and dense material which does not absorb water, making runoff from heavy fog and mists possible. Further explorations from this area shows that this population connects up with what Ritter, who apparently only knew of the most inland populations which are not as solitary or robust, named *C. pseudocoquimbana* var. *domeykoensis*. I have chosen to treat it as a form until further research determines if it is worthy of subspecies (or species) status.

Unlike the well known Domeyko valley populations, *C. coquimbana* 'Domeykoensis' is, in its core area, generally solitary. Old plants can be 900 mm long and tend to fall over under their own weight. These old plants usually only have one or two side stems, which arise from the main body well above the base. About 20% of the mature plants are clumping, with the majority having only two or three stems. The general appearance of the plant's shape, when seen from directly above, is of *C. echinoides*, however this plant is usually quite squat. The ribs of *C. coquimbana* 'Domeykoensis' are very distinct and the spines are neatly arranged and do not obstruct the view of the stem to the degree that other forms of the species generally do. Plants flower when only 50 mm in diameter and have relatively large flowers, fruits and seeds, all of which are reminiscent of *E. echinoides*.

The population of *C. coquimbana* 'Domeykoensis' is healthy, with very few dead plants present. Young plants down to 40 mm are very common. There appear to be tens of thousands of individuals which can have densities of about one plant per ten square meters. Associated cactus are *Eulychnia acida*, *Miguelopuntia migquelii*, *Trichocereus* sp. and an occasional *Eriosyce* (*Neoporteria*) species. Plants almost always grow on north facing slopes.



- ▲ Single headed *C. coquimbana* 'Domeykoensis', growing 45 km inland from the coast. Plants here are more yellow spined because fog seldom penetrates this far. The stems are also smaller and offset more.
- ◀ A grouping of typical *C. coquimbana* 'Domeykoensis'. The largest plant has a stem diameter of 150 mm.



- ▲ One of the features of *C. coquimbana* 'Domeykoensis' in its core area is its tall and mostly single stems. Unlike most *C. coquimbana*, which typically branch low down to form compact mounds, this plant often offsets from higher up on the stem in the manner of *C. cinerea*.
- ✦ *C. coquimbana* 'Domeykoensis', growing inland near their furthest extent into the desert. This is the population which Ritter knew and named. He appeared to be unaware of the western populations where plants are often solitary and grow larger.
- ◀ Stems of *C. coquimbana* 'Domeykoensis' can be up to 900 mm long and have only a few offsets. They eventually fall over and continue to grow with the old stem horizontal.



▲ The population, while small, has a high density. Here, five plants are growing close together.

▼ Habitat of *C. humilis* ssp. *australis*, looking north over the Huasco valley. Note the burrowing rat diggings.

C. humilis ssp. *australis*

First described by Paul Hoxey in March, 2004 in the British Cactus and Succulent Journal, this plant extends the known distribution of the species to the south by over 100 km. At present, ssp. *australis* is known only from Cerro Colorado, a small hill (about three kilometers south of Huasco) which only reaches 490 m in elevation. The population is small but plants are abundant on the north-east side of the hill near the top. Plants offset prolificly and grow in a variety of habitats from open ground to rock crevices. Plants are similar to other forms of *C. humilis* in having a relatively soft and small body growing from a thickened root via a narrow neck. The ribs are indistinct and the tubercles are prominent. Aside from its isolated distribution, a unique and easily distinguishing characteristic on mature plants is the presence of long and thick central spines (usually five) surrounded by spreading, short and thin radials (from five to nine).



The habitat for *C. humilis* ssp. *australis* receives more and regular winter rainfall than the *C. humilis* from further north. Plants are however seriously drought stressed for much of the year because the location is windy and the fog layer is usually at higher elevations. *C. humilis* ssp. *australis* grows with numerous *C. coquimbana* 'Fiedleriana' as well as *Eulychnia acida*, *Eriosyce napina* and the occasional *E. villosa*.

During the spring of 2004, the habitat was heavily infested with burrowing rats, which were undermining large areas of soil. *C. humilis* ssp. *australis* seemed to only occur where digging did not take place, suggesting that plants which appeared to be growing in loose ground were actually protected underground by larger rocks which prevented the rats from undermining the area. The rats feed on bulbs and succulent roots of non-cactus species and appear not to directly damage *C. humilis* or *C. coquimbana* directly. The habitat is not otherwise threatened as it is far enough removed from human development to be left alone.

There are a number of other hills to the south of the habitat which could support additional populations of *C. humilis* ssp. *australis*. None of the hills along the immediate coast have easy access so it may be some years before an intrepid copiapo enthusiast explores the coastal hills further in search of additional populations.



▲ Typical clump of *C. humilis* ssp. *australis*, during a dry year. The fine radial spines are only visible under close inspection.

▤ Plants flower during late spring. The new brown spines on this plant show that this plant has benefited from a wet spring.

▥ Plants often form clumps composed of numerous offsets.





- ▲ *C. coquimbana* from near Chequeque. Compare this with *C. marginata*, page ??? and *C. rupestris*, page ???.
- ▼ *C. coquimbana*, 30 km inland from Sarco. This mid-morning photograph still shows the coastal fog in the distance.



Endnotes: chapter 6

(4) In his early publications, F. Ritter gave species names to a number of plants which today are all considered to be forms of *C. coquimbiana*. In his 1980 book, he includes *C. pendulina*, *C. coquimbiana*, *C. pseudocoquimbiana*, *C. vallenarensis*, *C. fiedleriana* and *C. alticostata* as species. For varieties, he lists *C. coquimbiana* var. *armata* (high elevations in Rio Choros Valley), *C. pseudocoquimbiana* var. *chaniarensis* (growing in the alluvials nearer the coast), and *C. pseudocoquimbiana* var. *wagenknechtii* (from the Elquí valley). Unfortunately, he did a relatively bad job of sorting out his *C. coquimbiana* varieties as he seems to report several times that two or even three taxa as coming from the same location. This cannot be the case, as this would mean that they are all transitional forms not worthy of taxonomic status. The problem is that many (if not most) populations have individuals which would fit into several of Ritter's *C. coquimbiana* varieties, making the whole exercise of splitting up the species into varieties pointless and misleading. It seems that since F. Ritter, no one, including myself has been able come up with a coherent division of this large species. Everyone who spends time in habitat examining *C. coquimbiana* quickly realizes that there are many different 'types' but when attempts are made to quantify the features which make these types different, the set of characteristics prove sometimes to not even apply to the whole population. See photos, pages ??? and ??? for examples.

(1) Copiapoas are often found growing on river terraces as these are well drained, nutrient poor and thus not favored by other plants which would compete with the copiapoas for light and water. The Huasco river valley downstream from Vallanar has some amazingly thick river terraces, the highest of which stand at least 100 m above the present river level. They are composed in their full height of well rounded river boulders ranging up to 1 m in diameter, inter-spaced with gravels, sands and silts. The topmost terraces are in some places almost 1 km wide. It is assumed that these were deposited during very wet periods which would have corresponded to the warming period after the last several ice ages.

(2) The presence of a enlarged taproot is considered a significant plant trait worthy of including as a taxonomic discriminator. Unfortunately, not all species said to have taproots always do (and vice versa). *C. coquimbiana* is a good example, with many populations having a swollen taproot. This either disappears with age or was never present, causing confusion for anyone trying to use the root system as a diagnostic characteristic. Perhaps the taproot disappears with age or does not form if the plants are not stressed for some years during their early development.

(6) During September of 2005, a new and unexpected population of *C. coquimbiana* was found growing on the high hills near Chequeque. This mining area is 40 km inland from the coast and on the east side of the Pan American highway. It is isolated from the Vallanar valley populations by at least 15 km. The plants grow only above 1100 m, with the highest plants spotted growing up to at least 1400 m. With a 1700 m and a 2200 m peak nearby it remains to be seen how high this population grows.

(5) The entire Chilean coastline is being uplifted at a very rapid geological rate. It has been estimated to be up to 10 mm per year, which over a century is enough to strand beach boulders high and dry, where they become new habitat for colonizing species such as copiapoas.

(3) The southernmost *C. coquimbiana* are restricted to north facing coastal cliffs where they can only survive because competition for light from other plants is slight. Old plants eventually elongate, especially if growing with less sun. F. Ritter called this obvious geographic and environmental variant *C. pendulina* however when plants are grown from seeds, they show none of the elongation seen in some habitat plants; unless of course, they are grown in shade, but this would cause all species to elongate.

Copiapoas: Caldera to Huasco

Copiapoa coquimbana 'Fiedleriana'

Copiapoa dealbata

Copiapoa echinata

Copiapoa echinoides

Copiapoa humilis ssp. *longispina*

Copiapoa megarhiza ssp. *megarhiza*

Copiapoa megarhiza ssp. *borealis*

Caldera to Huasco

Huasco lies at the mouth of the Vallanar river, near 28°30' south latitude. This is 160 km south of the town of Caldera at 27°10'S. Map 1 show this area in relation to the distribution for the genus and the area covered in 'Copiapoa 1996'. In terms of north to south length, the Caldera to Chañaral sector is 90 km in extent and the Caldera to Huasco sector is 160 km in length.

The environment of the Caldera to Huasco area differs from the northern sector in a number of ways. Unlike the northern sectors which have narrow coastal plains and steep hills, the Caldera to Huasco area generally has a wide, often sandy coastal plain and low, more gently sloping hills which vary in height from 300-700 m. The northern sector was essentially rocky throughout while the Caldera to Huasco area has extensive sandy plains and partly stabilized dunes covering sections of the coastal plain. The northern sector has only small narrow valleys breaking up the almost continuous coastal escarpment. The Caldera to Huasco area is characterized by being dissected by numerous, shallow but wide alluvial filled valleys and is bordered in the north and south by the wide and deep Copiapó and Vallanar valleys, both of which are used for agriculture. Formerly,

▲ The lower Copiapó Valley, looking northeast. This wide expanse of sandy soil is characteristic of the flat terrain often found between Caldera and Huasco. In the foreground is *C. megarhiza* ssp. *borealis* growing in stabilized sand dunes.



both valleys were vegetated by river edge forests which were watered by the snow melt runoff from the Andes. Unlike the true desert further north, the Huasco area is bordering on being semi-arid and is characterized by a low growing but extensive shrub layer, particularly on the south and east facing slopes. Winter rainfall generated from frontal activity in the Caldera to Huasco area is more regular, particularly in the south, where about 50 mm annually is the norm. Years can go by without any significant rainfall while other years may have three or four times the average rainfall. Frost may be a factor in limiting where and how far inland copiapos can grow in the Caldera to Huasco area. The average height of the fog layer appears to be lower in the south as evidenced by the much lower elevation that lichens growth on eulychnias and copiapos.

In terms of similarities, the northern sector and the Caldera to Huasco area share a number of features. Fog is important in maintaining low evaporation and transpiration, particularly near the coast. The temperature pattern is similar if somewhat more pronounced in the Caldera to Huasco area where the winters are cooler. Frost is not a factor influencing copiapos along the coastal strip in both sectors. Plants and animals associated with copiapos appear to be similar in both sectors but are much more abundant and increase in diversity towards the south.

For information on the changes that a wet winter brings to the environment, see pages ????

Associated organisms

A number of plants associated with copiapos which are common in the northern sector do not occur in the south. In the north, *Dueterocohnia chrysantha* is important in soil stabilization, especially on talus slopes. It appears not to grow south of Caldera. *Puya boliviana* grows in the northern sector on steep shady south or east facing slopes. This species is rare in the south but is replaced by other puya species in similar habitats. *Eulychnia* species continue their association with copiapos but the species are different with *E. breviflora* and *E. saint-pieana* in the north being replaced by *E. acida* ssp. *procumbens* and *E. acida* ssp. *elata* in the Caldera to Huasco sector. *Eriogyne* species (sensu Kattermann) appear not to increase in numbers of individuals in the south but do change species, becoming more diverse and variable. Only *E. taltalensis* (several forms), *E. odieri* and *E. recondita* grow in the northern sector while at least six species (*E. villosa*, *E. sociabilis*, *E. crispa* [several forms], *E. aerocarpa*, *E. odieri* [several forms] and *E. napina*) being found in the Caldera to Huasco area.

The animal association in the Caldera to Huasco sector are more



A *C. echinoides* flower. Most of the southern species have a very spiny apex which prevent the petals from fully opening. The spines also protect the petals from grazing animals.

▼ A copiapoa on a foggy morning. The spines on the left (southwest side) are wet but not the the point of run-off. Fog and wind are both important in shaping the appearance of copiapoa mounds.





▲ Lichen growth is heavy on plants above about 200 m at which elevation the fog layer is persistent and long lasting. This *C. echinoides* near Caleta Pajonal has covered over much of the stem and spines, mainly on the southwest facing sides from where the prevailing wind blows.

▼ Recent activity of colonial burrowing rats digging among a population of *C. megarhiza* ssp. *borealis*. Large areas of ground are regularly upturned by the rats as they search for bulbs and tubers.



diverse and greater in actual density, largely because of the increased plant diversity and cover. The major predator of copiapos is still the guanaco which is common in the Caldera to Huasco sector, especially where human settlement is sparse. Wild donkeys are also found in increased numbers. Goats, all of which appear to be domesticated, are common in areas where permanent water is found. This is usually in the middle to upper reaches of the smaller valleys, such as the Totoral and Carrizal Valleys, where water occurs as seepages in the valley bottoms or as small springs higher up on the hillsides. The vegetation near goat grazed areas is very sparse and the soils are very eroded and modified by the actions of goat hooves. Near permanent water, the only plants remaining are mature copiapos, indicating that goats have not learned to penetrate through the spine covering to get to the edible inner tissue in the same way as guanaco and donkeys.

While not able to identify the rodent fauna, we did notice a great increase in the activities of what appeared to be native mice and rats on both copiapos and other plants. We believe this to be due to the good rains following the El Niño years of 1997 and 1999 and the better than average rains of 1998, 2000 and 2003. Burrows in soft soil and sand were very common, these being so extensive and deep that walking over such areas resulted in continual breaking through of the shallow soil crust into the the below ground burrows. In some areas fresh looking mice and rat feces was also frequently found among copiapoa clumps but not as frequently as in the northern sector where it appears a mice 'plague' was occurring (2001).

The effect of man, while still minimal when compared to areas where rainfall is suitable for agriculture, is greater than in the northern sector. The proximity of large inland population centers has resulted in a number of seaside summer holiday settlements along sections of the coast, particularly north of Huasco and south of Caldera. The Huasco summer settlements spread along the coast for several kilometers and have resulted in the destruction of some *C. fiedleriana*, *C. echinata* and *C. echinoides* populations. On the other hand, mining is much less than further north and a lack of a good coastal road north Carrizal Bajo has protected this sector of the coast from development. In the last few years the harvesting of shellfish and seaweed has resulted in coastal roads being improved and itinerant settlements being established along the rocky shoreline. Chile has a long term plan of creating a coastal road along its entire coast and when completed, it will make it easier for Copiapoa enthusiasts to visit formerly difficult to get to locations⁽¹⁾. It will also increase the chances of environmental damage to copiapoa populations near its path.

Distribution of the genus

Copiapoas do not occur continuously in the Caldera to Huasco sector. This contrasts to the northern sectors where copiapoas could generally be found within view anywhere along the coast from at least the Botija Valley to just north of Chañaral. The discontinuous nature of Copiapoas distribution in the Caldera to Huasco sector is due to a lack of rocky hillsides, the presence of unsuitable sandy areas along the coastal strip and the sandy nature of many of the lower valley sediments, especially the Copiapó valley.

In the Copiapó valley, *C. megarhiza* ssp. *megarhiza* has been recorded about 10 km inland from the city of Copiapó. This is 70 km from the coast. It grows only about 10 km westwards, before gradually forming transitional populations to *C. megarhiza* ssp. *borealis*. This plant grows on low hills in and just south of the valley towards the sea. Near the coast and south of the Copiapó valley, there is a large coastal plain which forms a distribution barrier to copiapoas before rocky outcrops again provide a suitable habitat. Here, *C. echinata*, which only grows at low elevations, grows on rocky outcrops and hillsides, extending to within 25 km of Huasco. In the same area, but also extending further inland, *C. echinoides* grows in a variety of habitats. It can grow inland up to 30 km from the sea but only on rocky outcrops. Near the sea it occasionally grows on sandy alluvial plains. *C. dealbata* has its northernmost range just south of Totoral Bajo, extending south to within 25 km of Huasco. *C. humilis* ssp. *longispina* only grows in a few low hills not far from the Pan American highway at around 650 m elevation.



▲ *C. fiedleriana*. The largest stem is 65 mm in diameter. Note the pronounced 'chin'. This photo was taken during a dry year when the plant body is more pulled in than normal.

▼ *C. fiedleriana*, growing 10 k north of Huasco at 30 m elevation.

C. coquimbana 'Fiedleriana'

First described in 1903, *C. fiedleriana* has been tossed about a number of times, sometimes it is granted species status, other times it is relegated to a subspecies or just a form of *C. coquimbana*. I treat it here as a form of *C. coquimbana*.

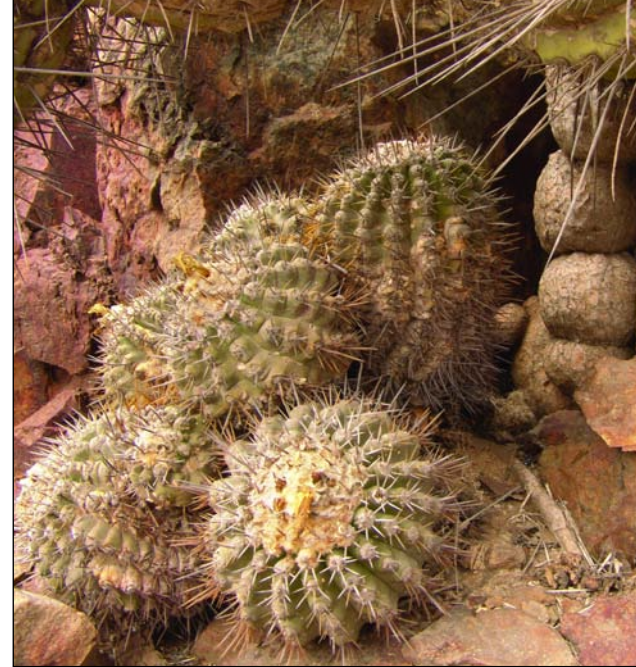
It is said to be distinguishable by its olive-green color and its chin-like folds below the areoles, however these traits are also exhibited by some *C. coquimbana* populations many kilometers to the south. It is also said to be distinguished from the *C. coquimbana* by its compact growth and small, spherical stems but this feature is also typical for some populations of *C. coquimbana*. Photographs of 'pretty' *C. coquimbana* 'Fiedleriana' will show a plant with few spines and showing much stem tissue, often with a brownish body. Often not far distant are less 'attractive' plants which do not look the type, in fact, many of them would pass for relatively typical *C. coquimbana*. While *C. coquimbana* 'Fiedleriana' has a thickened taproot, at least on single headed plants, this feature is also not diagnostic as both *C. megarhiza* and many *C. coquimbana* also have the same type of roots. Because it grows and hybridizes with other forms of *C. coquimbana*, I recommend that *C. fiedleriana* be dropped as a taxon and that it be considered one of the many forms of *C. coquimbana*.



C. coquimbana 'Fiedleriana' grows near Huasco and to the north, where it grows with *C. echinoides*. It is said to merge with typical *C. echinata* but I have been unable to find any location where the two taxa come together. It also grows with *C. coquimbana* south of Huasco. Plants extend inland into the Huasco valley where they gradually become taller and merge into *C. coquimbana* 'Vallanarensis'. To the south of Huasco, the chin feature persists until Sarco, where it gradually becomes less pronounced.

Generally, populations of *C. coquimbana* 'Fiedleriana' visited had only an occasional flower but showed signs of previous profuse flowering, a feature shared by both related species. It appears that *C. coquimbana* 'Fiedleriana' flowering is seasonal, being in spring. However, a few ripe fruits as well as buds were occasionally found during winter.

This plant is only endangered in the near coastal part of its range through coastal holiday home urbanization. Plants on the steeper, rocky hillsides are also endangered by goats which graze throughout the area during winter and when unseasonal rains bring a covering of annuals. While goats do not eat copiapos, they do significant damage the surface covering and dislodge rocks and plants, making regeneration unlikely.



▲ A *C. fiedleriana* growing out from under a large *Eulychnia acida*. Such plants are protected from the weather and appear quite different from plants growing in exposed situations (below).

▼ *C. fiedleriana*, growing on coastal rocks near the holiday houses 10 km north of Huasco. This area is rapidly expanding, endangering the habitat.





C. dealbata

(including *C. carrizalensis*)

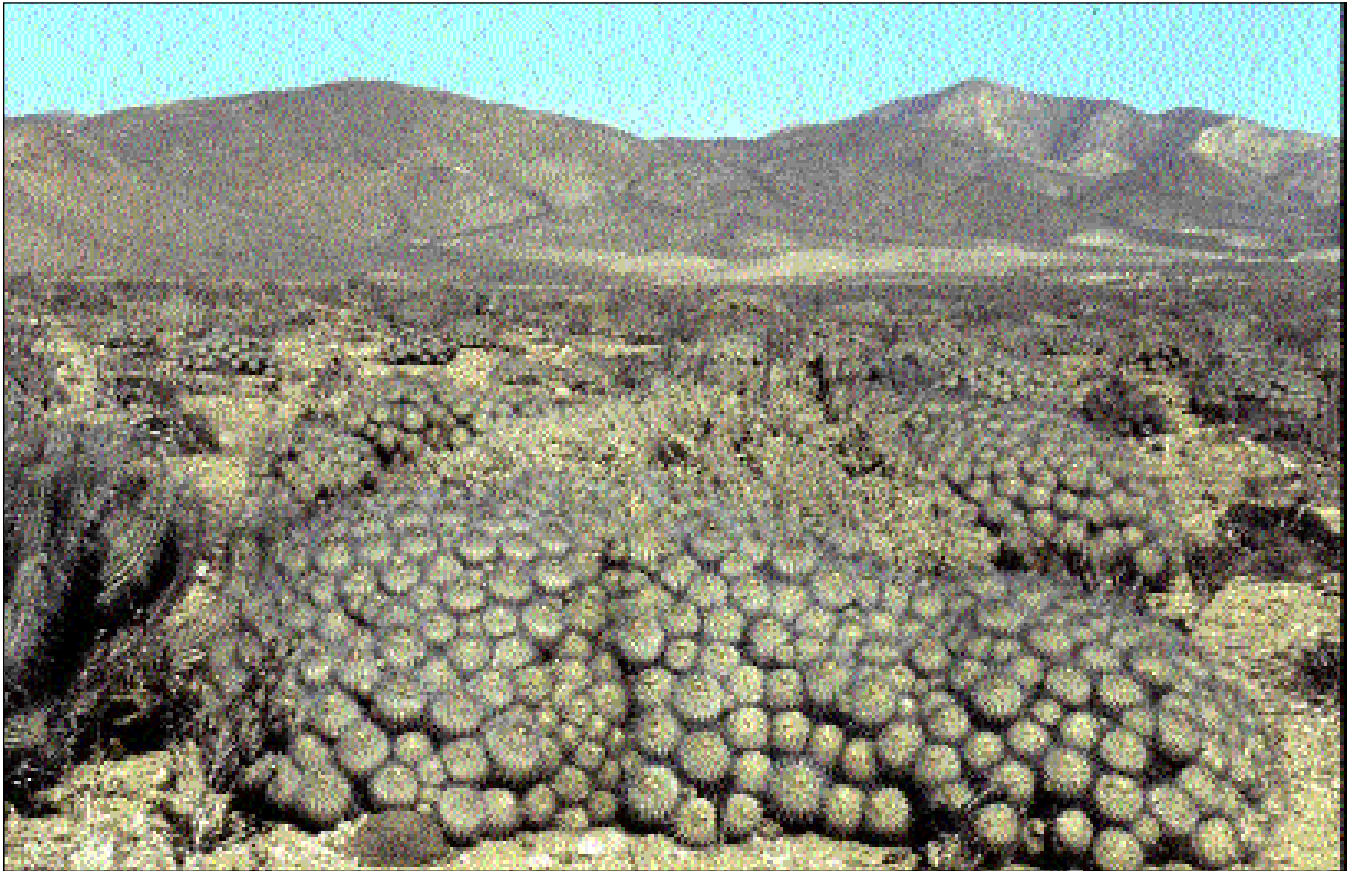
C. dealbata generally grows into compact clumps which can be over 2 m in diameter. The oldest stems are often long and sometimes reaching 2 m. Most stems generally have profuse offsetting from along their length, creating a compact mounds in many specimens. The less attractive, and hence seldom photographed plants, have long and floppy stems with fewer offsets and form open, irregular mounds which have lots of blackening along their lower stems. The stems are hard, the spines straight and the epidermis can be either white with wax or green (mostly in the north of the range). The ribs are shallow and the areoles are prominent, making this species one of the most recognizable.

C. dealbata is found from just a few kilometers south of Totoral Bajo to about 12 km north of Huasco. The distribution of *C. dealbata* is not continuous with many apparently suitable habitats not having plants. Aside from the northernmost area of scattered distribution, plants appear to mainly grow in dense colonies, preferring a north to west exposure. Steep rocky hillsides did not support as many *C. dealbata* as flatter habitats. *C. dealbata* does not extend far inland, with the Carrizal Valley having the last plants some 9 km inland. Between

▲ *C. dealbata* showing offsets. Since the rains of 1997 many plants have produced offsets at a rate which appears to be greater than previous growth periods. This same phenomenon was noted in many copiapoa species from north of Caldera.

▼ *C. dealbata* showing extreme variation in spine length and stem color. Many of these plants from north of Carrizal Bajo were only slightly white. This form was given the name of *C. carrizalensis* by Ritter.





Carizzal Bajo and Huasco, plants grow on sandy, shrub covered slopes as well as rocky areas. Some granite hills have populations while others, which appear to have the same conditions, do not support plants. Plants growing in the valleys extend further inland. In the north, plants appear to be found only along the coastal rocks but in the central and southern area of its distribution the species grows up into the coastal hills to at least 600 m, making it a mountain species. Plants at higher elevation show the greatest variability and the best health, indicating that the core area is high in the coastal mountains.

Stem variability is the greatest just north of Carizzal Bajo, especially in the La Higuero Canyon population. Here, some plants were very *C. cinerea*-like in growth form, having wide, tall stems (to 1 m) and few offsets. These plants are generally in poor condition, being stressed and without new growth. Plants with more spherical heads and forming compact, tight mounds do much better, showing more wool and a much higher incidence of flowering.

Spination on *C. dealbata* varies mainly in intensity, length and thickness. Very stressed plants often lose many spines and often look attractive but the apex is always pulled in, indicating a lack of new growth (see photo page ??). Heavily spined plants grow intermixed with less spiny ones and it appears that this feature is very random

▲ A large mound of *C. dealbata* which is composed of four sperate plants which have inter-grown. This population north of Carrizal Bajo is very dense and extends up to the tops of the hills in the back-ground.

▼ Old, non-growing stems of *C. dealbata* lose their spines and pull in at the apex. The lack of apical wool is an indication that this plant has not grown for many years. Such stems rarely flower and will soon die.





- ▲ Many *C. dealbata*, are blackened by blue-green algae on their shadier lower stems. This specimen has longer than average spines.
- ▼ *C. dealbata*, viewed from the south side. Plants have a decided north tilt with the shady side being much more open and 'leggy'.
- ▼ *C. dealbata*, showing variation within the species.



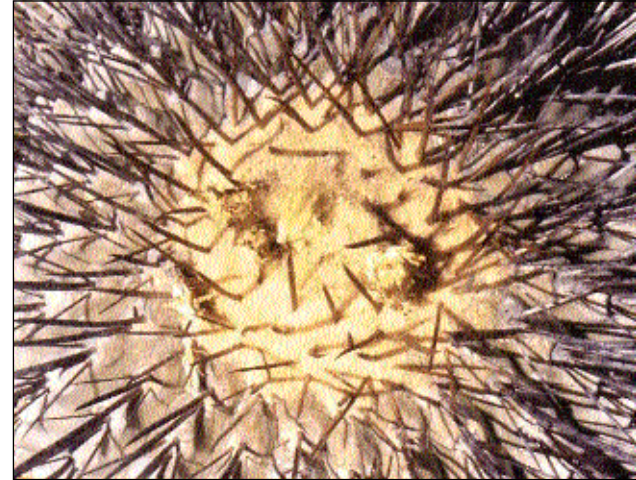
C. dealbata

(including *C. carrizalensis*)

C. dealbata generally grows into compact clumps which can be over 2 m in diameter. The oldest stems are often long and sometimes reaching 2 m. Most stems generally have profuse offsetting from along their length, creating a compact mounds in many specimens. The less attractive, and hence seldom photographed plants, have long and floppy stems with fewer offsets and form open, irregular mounds which have lots of blackening along their lower stems. The stems are hard, the spines straight and the epidermis can be either white with wax or green (mostly in the north of the range). The ribs are shallow and the areoles are prominent, making this species one of the most recognizable.

C. dealbata is found from just a few kilometers south of Totoral Bajo to about 12 km north of Huasco. The distribution of *C. dealbata* is not continuous with many apparently suitable habitats not having plants. Aside from the northernmost area of scattered distribution, plants appear to mainly grow in dense colonies, preferring a north to west exposure. Steep rocky hillsides did not support as many *C. dealbata* as flatter habitats. *C. dealbata* does not extend far inland, with the Carizal Valley having the last plants some 9 km inland. Between Carizal Bajo and Huasco, plants grow on sandy, shrub covered slopes as well as rocky areas. Some granite hills have populations while others, which appear to have the same conditions, do not support plants. Plants growing in the valleys extend further inland. In the north, plants appear to be found only along the coastal rocks but in the central and southern area of its distribution the species grows up into the coastal hills to at least 600 m, making it a mountain species. Plants at higher elevation show the greatest variability and the best health, indicating that the core area is high in the coastal mountains.

Stem variability is the greatest just north of Carizal Bajo, espe-



- ▲ The apical area of a healthy and growing *C. dealbata*. Note the new brown colored spines come from deep within the wool.



- ▼ *C. dealbata* at Caleta de los Burros, north of Carrizal Bajo. This is the northernmost population of any size for the species.

- ◀ A relatively young healthy *C. dealbata*, growing at 400 m elevation south of Carrizal Bajo.

- ▶ *C. dealbata* growing about 10 k south of Totoral Bajo. This northern population has green colored stems with only a very thin coating of wax. This corresponds to Ritter's *C. carrizalensis*.

- ▼ This *C. dealbata* has the growth form of some *C. cinerea*. Such variation is not uncommon.





▲ A typical *C. echinata*. The largest stem is about 60 mm in diameter.

▼ *C. echinata* are often found growing in slight depressions where the guanaco had scraped away the surface covering of rocks to get at the plant's root. With this plant, it appears that the digging occurred many years ago during a severe drought. In the meantime, the thick root has re-sprouted several new heads.

C. echinata

C. echinata is usually assumed to be a variety of *C. megarhiza*, which Ritter was the first to propose. I remain unsure that this is the case and treat it here as a species in its own right.

Most often seen as a small very spiny clump of from 5-10 heads, *C. echinata* can grow to about 1 m with over 100 heads in favorable situations such as alluvial soils in river valleys. Typically, the spines obscure the body, making it difficult to count the number of ribs or see the body color. Mature spines quickly fade to a gray color. Plants have a thickened taproot, especially when small. While we saw no signs of recent guanaco damage to stems, it was apparent from the soil disturbance that many plants had been interfered with by digging animals. Often plants occurred in slight depressions where stones had been scraped away (see photo page ??). Stem regrowth was apparent, these stems were smaller than plants growing among larger rocks. I interpret this as guanaco digging at the ground to get at the tuberous roots rather than eating the stems themselves. As we did not document any recent digging of this species up to 2005, there is no evidence when the plants were last extensively interfered with.

C. echinata is very widespread, extending from northeast of Caleta Pajonal to Punta Lobos north of Huasco. It is essentially a coastal





species which grows under 200 m of elevation. It is most common on the rocky coastal plain where it is often very abundant, especially in the north of its range where populations can reach densities of over 2 plants per m². While we found plants growing up to eight kilometers inland, the largest and healthiest populations were on the coastal plain at low elevations. The species does not grow on sandy areas, preferring rocky ground or rubble.

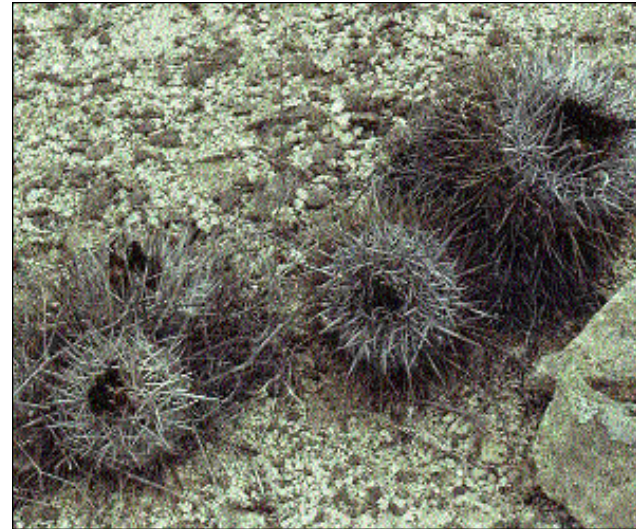
Flowering of *C. echinata* appears to be strongly seasonal or rain event triggered however occasional plants were found with buds, flowers and fruit of varying ripeness. Reproduction did not appear to be synchronized within a population, with plants in various stages of flower development occurring occasionally throughout the whole population range.

The population age structure of *C. echinata* is very skewed toward adult plants with multiple heads. Single headed plants almost always turned out to be regrowth from an enlarged tuberous roots instead of seedlings.

C. echinata grows with *C. dealbata* and *C. echinoides*, neither of which hybridize with it. In the south, it grows to within a few kilometers of *C. fiedleriana* (see pages ???) but I have not found anywhere where both taxa grow together or hybridize. In the north, it grows to within 10 km of the southernmost *C. megarhiza* ssp. *borealis*.

▲ *C. echinata* growing on the coastal plain north north of Carrizal Bajo. The plants in the foreground are among the largest that we found, with the average plant having only about eight stems.

▼ Typical *C. echinata*, growing north of Carrizal Bajo. Most populations are composed of plants which only form small clumps. The lack of lichen indicates that it is growing near the seashore.



Copiapoa echinoides

(including *C. dura* and *C. cuprea*)

E. echinoides is a variable taxon in both size of clumps. Size of heads, shape of stems, spininess and especially color of the epidermis, varied within and between populations. All plants however share the hard body, thick spination and relatively shallow ribs features. The root, especially on inland stressed plants can become very thick but it can also be lacking, especially on coastal plants. The dramatic epidermal color variability had Ritter giving the name *C. cuprea* to plants showing a coppery color. Plants with this feature are scattered among plants with a green epidermis at many sites however at some places they form uniform populations, especially on hot, dry northerly aspects. Some growers report that habitat collected plants retain their epidermal color in cultivation, others have had them rapidly turn green. Some plants have erect, elongated stems and form clumps with only a few offsets while other plants form dense, low clumps with stems wider than they are high. Intermediates of all forms are widespread, indicating a variable taxon rather than separate varieties or species. In the Totoral Valley, inland plants are dark green, becoming coppery towards the coast while in the Corrizalillo Valley the plants are green with small heads near the sea and large, wide and with cop-

C. echinoides (left) in the Carizalillo Valley, north of Huasco. This is near the southernmost edge of the distribution. The plant on the right appears to be a hybrid with *C. coquimbana*, which grows nearby.



perly colored stems in the upper valley. The Totoral Valley also has a miniature form (form 'Nana', see photo page ???) which could be easily mistaken for a different species. Ritter (1980) dropped the name *C. echinoides* in favor of either *C. cuprea* or *C. dura* without a clear reason. The ISO has kept *C. echinoides* and dropped *C. cuprea* and *C. dura* with which I agree.

C. echinoides grows north to at least 27°30'N. Further north there are extensive areas of sand. The isolated higher hills, which reach over 300 m in elevation, contain populations of *E. megarhiza* var *borealis*, however these are 10 km distant. Further to the south, *C. echinoides* occurs on coastal rocks in association with *C. echinata* with which it does not appear to hybridize. It extends into the inland via the valleys to at least 30 km from the shore. It is one of the most drought resistant copiapos, growing just a bit seaward from the most inland eulychnias which are the most drought resistant cactus of the area. Surprisingly for me, the largest plants found (see photo page ??) were not far from the sea at the northern end of its population, growing as isolated individuals on shallow sloping alluvial gravel deposits. The most inland plants of *E. echinoides* are very stressed and suffering badly with many dead plants present. The most stressed plants were not very different from some *C. megarhiza* (see photo, page ??). These inland *E. echinoides* also had a highly developed taproot not dissimilar to plants of *C. megarhiza* ssp. *borealis*. Plants of *E. echinoides* along the wind swept rocky coastal plain usually had only 3-6 heads and formed compact clumps which were wider than high. In sheltered positions however, the plants grow taller, wider and had

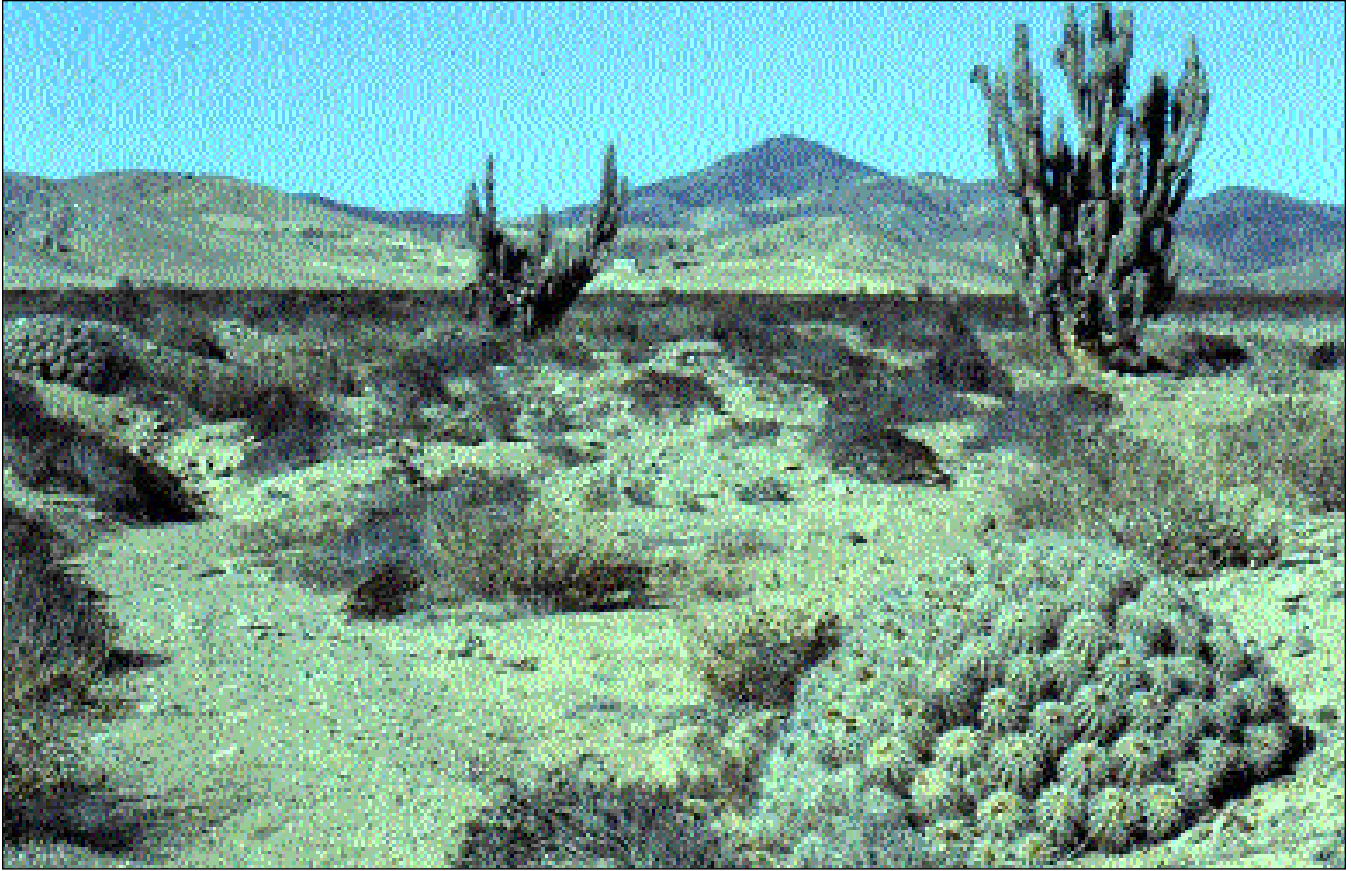


▲ A fiercely spined *C. echinoides*. Often the apical spines are so close together that the petals are unable to fully open.

▲ *C. echinoides* growing on the alluvial gravel deposits inland from Caleta Salida. This is near the northernmost distribution for the species.

▼ A tall growing *C. echinoides* from east of Totoral. The body colour here is generally dark.





▲ *E. echinoides* growing on alluvial valley deposits inland from Totoral.

▼ Small plants of *E. echinoides* are rare. This one has a slightly thickened taproot.



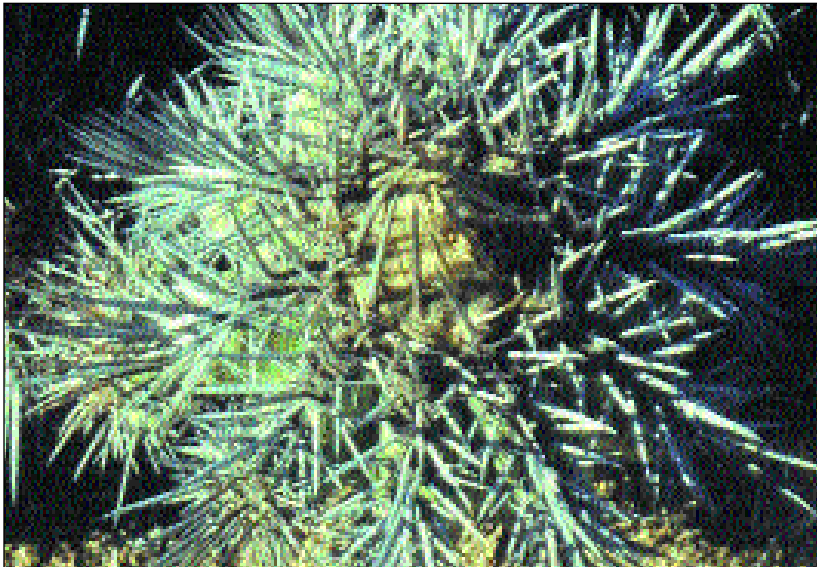
less spines, indicating that spination and growth characteristics are highly influenced by environmental factors.

C. echinoides does not appear to hybridize with *C. echinata* or with *C. dealbata*, both of which it grows with. In the southern part of its range (Huasco Valley) *C. echinoides* tendencies are evident in populations of *C. coquimbana*, indicating widespread gene interchange. In the south, it can be difficult to decide which name to use for many individual plants where the majority were clearly *C. coquimbana*. Even as far south as the Domeyko Valley (40 km south of the Huasco Valley) the most inland populations of *C. coquimbana* (Ritter's *C. pseudocoquimbana* var *domeykoensis*) appeared to have *C. echinoides* tendencies (fewer, shorter and less spreading spines, thick stems showing body color and an epidermis which can be somewhat coppery). For me, *C. coquimbana* 'alticostata' (see Charles, 1980, p. 38) from the Huasco valley shows many *C. echinoides* tendencies and is best be considered to be an intermediate between *C. coquimbana* and *C. echinoides*.

C. echinoides is not endangered in very many places. Because of its wide distribution in an area not well developed, most populations are safe from disturbance.



◀ The author with a large *C. echinoides* 'Magnifica' growing on north facing hillsides in the upper part of the Quebrada Corrizalillo. This was one of the largest plants located, with some stems reaching 250 mm in diameter. The shallow ribs are especially noticeable on plants with short spines, such as this.



◀ *C. echinoides* 'Cuprea' growing under stressed conditions. Note the variation in stem size and spines, which was typical for most populations.

▶ *C. echinoides* "Nana", a miniature form which grows on a few barren rocky hills east of Totoral. Plants flower when only 30 mm in diameter. Nearby hillsides have more typical sized plants.

▶ Many *C. echinoides* are spiny and sometimes resemble *C. coquimbana* in general appearance. This plant, photographed north of Carrizal Bajo, was growing among less spiny and 'nicer' plants which would generally be the choice of photographers.





▲ A healthy *C. humilis* ssp. *longispina*. This plant is growing up from the base of a now dead larger plant. Note the flower bud. (photo: Ricardo Keim)

▼ Habitat of *C. humilis* ssp. *longispina*. Plants grow mostly on north facing slopes, either on decomposed granite or in rock crevices. The relative lushness of the vegetation reflects unusual spring rains two months prior. (photo: Ricardo Keim)

C. humilis ssp. *longispina*

C. humilis ssp. *longispina* differs from *C. humilis* ssp. *humilis* by having longer and thicker spines, especially on old plants. It seems to be closely related to *C. humilis* 'Leonensis' (see page ???), which grows over 100 km further north.

First described as *C. longispina* in 1963, this plant was discovered in 1956 by F. Ritter, who mentioned that this plant is only known from one small isolated population south of Copiapó. This plant has eluded the author for many years and it was great gratitude that Ricardo Keim and Ingrid Schaub have shared their photographs and comments from their October of 2005 trip when they located the plant not far from the Pan American Highway. Unlike all of the other types of *C. humilis*, which are within the fog zone, the habitat of *C. humilis* ssp. *longispina* is 30 km away from the shore in a quite arid looking habitat. While it grows at around 650 m elevation, there is little to suggest that a *C. humilis* type plant would be found so far inland. The area however, frequently has heavy fogs, which roll in unhindered by tall hills, over the relatively flat coastal plain. Not far from this location there is a small population of *Tillandsia lembckei*, a



fog plant which carpets the ground and clings to low vegetation.

This population of *C. humilis* ssp. *longispina*, which grows on the northwest facing side of one small hill, is small and appears not to extend very far, suggesting that it is a relic population surviving from a time when plants extended over a much larger area. The best looking plants survive at the base of large rocks or in crevices where runoff collects. The presence of this population may be an indication that other small populations survive on nearby hills.

Plants of *C. humilis* ssp. *longispina* have a harder body than typical *C. humilis* (at least during the wet year of 2005). While some plants have long spines, others are less spiny. As with all copiapoa, inland populations, especially if at higher elevations, always have thicker spines than coastal plants, suggesting that this subspecies may only be a isolated outlying population of a once far more widespread and diverse *C. humilis*.



- ▲ This *C. humilis* ssp. *longispina* is growing in decomposed granite and is not as fully turgid as plants which would have had access to more water.

(photo: Ricardo Keim)



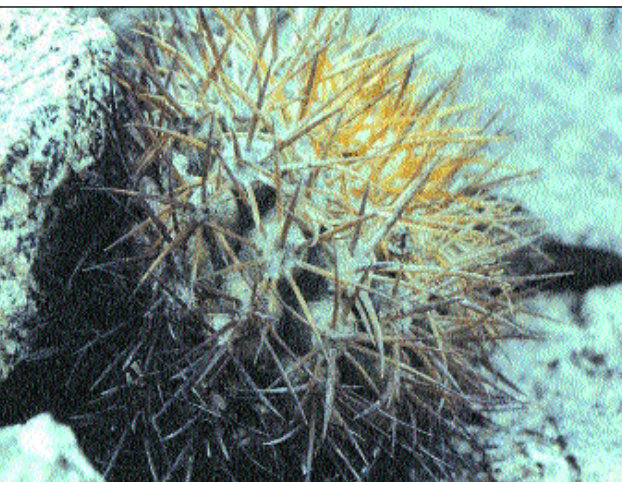
- ◀◀ Two *C. humilis* ssp. *longispina* growing in rock crevices.

(photo: Ricardo Keim)

- ▼ This old *C. humilis* ssp. *longispina* shows how plants eventually elongate and become very spiny. Most old stems have died at this location, however many of the roots have sent up new stems.

(photo: Ricardo Keim)

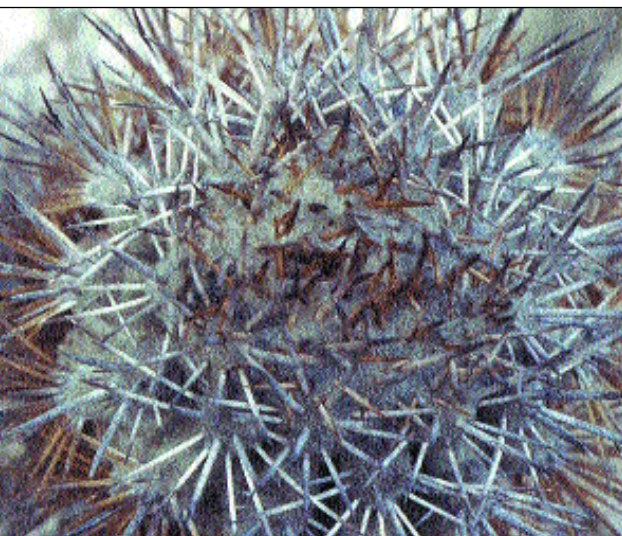




▲ *C. megarhiza* ssp. *megarhiza*. This 100 mm diameter plant was growing in a sheltered rock crevice and shows brighter spine coloration than typical plants. There is nothing to substantiate the claim that there are two forms of this species, yellow and dark spined, as this relates to only exposure.

▲ *C. megarhiza* ssp. *megarhiza* growing on alluvial valley deposits. Many plants growing here were larger and had more stems than those on the hillsides. The Pan American Highway is on the other side (east) of the hills in the background. The population of ssp. *megarhiza* extends to within 200 m elevation of the summit of the largest hill.

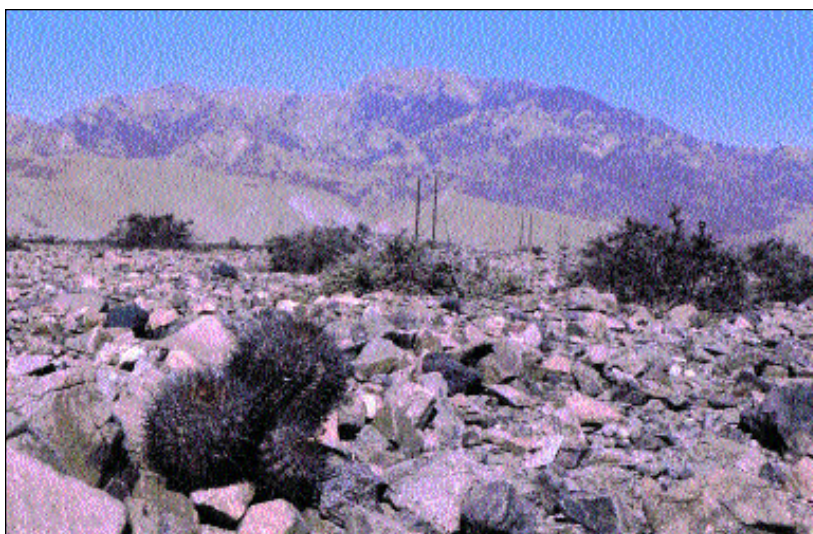
▼ *C. megarhiza* ssp. *megarhiza*. New spines are dark brown. As the spines age they become gray, most likely because blue-green algae grow on and inside the spines. With time, the algae dies and the oldest spines bleach to a golden brown color.



C. megarhiza ssp. *megarhiza*

C. megarhiza is characterized by thick spines and few stems. Spines are initially dark brown when new and quickly turn a dull gray, apparently as a result of algae growth on and in the spines. Plants in sheltered areas where fog does not penetrate freely have golden-brown spines on their lower stems, possibly because the algae have died and the spines have been sun bleached to their original color. Plants in exposed, west facing slopes retain the gray color lower down their stems. While older plants can have elongated stems to 350 mm, these are mostly dying or in poor condition. Multi-headed plants are not uncommon but most plants still alive are single headed, especially on the rocky north facing hillsides where stress is more severe than in the alluvial deposits of the valley. *C. megarhiza* mostly grows on north to west facing hillsides but occasionally plants also grow on east and south facing slopes. These plants, growing in what is not considered the typical 'ideal' environment, are often healthier than plants on the sunnier northern slopes. I assume this is because today the south facing slopes are no longer covered by shrubs and other perennials which would have provided competition for light and water during earlier times with the climate was wetter. Those copiapos on the north slopes are exposed to full sunlight and are drying out faster than the more shaded plants on east and south facing slopes. While south slopes may today be more 'ideal' for ssp. *megarhiza*, the species no longer has the ability to establish seedlings in such a hostile and dry environment, meaning that only long mature and established plants are surviving on the rocky hillsides.

C. megarhiza ssp. *megarhiza* is said to grow from just west of the city of Copiapó inland to the mountains east of Paipote, a mining town some 8 km east of Copiapó. Over the last decade a number of



Copiapoa enthusiasts have searched from *C. megarhiza* ssp. *megarhiza* between Copiapó and Paipote without success. The hills and mountains inland of Paipote have also been searched with no recent findings of ssp. *megarhiza* being located however no one to my knowledge has climbed high into the hills to check there. Ritter identified Toledo, an old railway station as the western limit of *C. megarhiza* ssp. *megarhiza*. This is about 8 km west of Copiapó. The area today is highly modified, with agriculture being extensive. Even the low hills in the valley proper have been destroyed by rock and gravel mining. To the south however, there is an extensive range of hills, facing west and north, which support a large population of ssp. *megarhiza*. Plants occur both on the hillsides and in the alluvial material within the valley floor. Several mining roads allow access up the valley to at least 750 m at which elevation ssp. *megarhiza* still occurs. Scanning of the hillsides with binoculars revealed that plants went at least 100 m higher up into the hills, making this taxon a mountain species rather than the valley one suggested by Ritter. I expect Ritter found many healthy plants growing in the valley of the Rio Copiapó, possibly near the railway station; land which is today totally occupied by agriculture. Another easy to reach and substantial population of ssp. *megarhiza* also grows on north facing rocky hillsides just northwest of the city of Copiapó at 550-800 m in elevation and is accessible via the dirt road which goes to mines to the north.

The populations of ssp. *megarhiza* which I have visited appears not to have produced seedlings for many years. The youngest plants were found growing in the bottoms of the small steep valleys in alluvial sand and gravel where they appear to have germinated after a rain event washed seeds down from plants growing on the hillsides. A number of small (25-40 mm) plants were found on the flat, wide alluvial deposits of the lower valley but these turned out to be regrowth from tuberous roots (see photo, right). Mature stems, especially elongated ones, are attached to the tuberous root via a narrow neck which becomes brittle with age. I found isolated loose stems lying about which had been dislodged by animals. The overall health of ssp. *megarhiza* appears to be good but since no regeneration is occurring the number of plants can only decline as mature plants die and smaller plants are collected. This taxon appears to flower well as after rain events. In some instances, up to five buds emerge at nearly the same time. New growth, indicated by brown spines, occurs shortly after rain events.



▲ *C. megarhiza* ssp. *megarhiza* growing on north facing rocky hillsides near Copiapó. Plants grew well up into the mountains in the background.

▼ *C. megarhiza* ssp. *megarhiza* stem growing from a large old tuberous root. The ruler graduations are 10 mm. The original stem had broken off cleanly at the narrow root neck.





C. megarhiza ssp. *borealis*

C. megarhiza ssp. *borealis* differs from the species in having thinner and smaller stems, roots and spines. It is the coastal version of the species which is much more widespread and easy to visit. The plants growing furthest inland look much like *C. megarhiza* ssp. *megarhiza*. Ritter gave the population which grows west of Copiapó the name of *C. echinata* var. *borealis*. His location for is from Monte Amargo (40 km west of Copiapó) but it is much more abundant on the numerous low, rocky hills which occur in the near-featureless sandy coastal plain. Some of the healthier populations contain large plants with up to 30 stems with clumps that reach 500 mm in diameter. Most of the larger plants are stressed or dying, again, fitting in with the general observation that large, open plants are not coping as well with long-term drought as smaller, more compact plants. Graham Charles (1998) commented that his acquaintances had found *C. megarhiza* ssp. *borealis* to be very stressed and in poor condition, with most plants either dead or dying. We believe this to be true for the plants

- ▲ *C. megarhiza* ssp. *borealis*. Plants have larger stems and thicker spines than *C. echinata* with which it is sometimes confused. It has thinner spines than typical *C. megarhiza* which grow further inland.
- ▼ *C. megarhiza* ssp. *borealis*, growing on old alluvial deposits in the Sierra Pinuno. Most surviving plants here have only five or six stems with all the larger plants have died.



growing on the low hills close to Monte Amargo but many of the more distant populations, especially those on higher hills, are faring well, with plants of all sizes being present. Occasional plants were in flower and in fruit throughout winter. While no seedlings were ever found, single headed plants down to 75 mm in diameter are present. Plants at this size are mature, with most showing signs of having flowered. *C. megarhiza* ssp. *borealis* not only grows on the rocky hills, but also on the stabilized shady slopes (see photo, page ???). This suggest that these sandy slopes were formerly more vegetated and less unstable than today, providing suitable habitat for seedling survival. Today, the smallest plants were in north facing rock crevices near the tops of the tallest hills.

C. megarhiza ssp. *borealis* does not grow with any other copiapoa species. In the south, it comes to within 20 km of the closely related *C. echinata*. In the north, it comes to within 20 km of *C. megarhiza* 'Leonensis'.



- ▲ *C. megarhiza* ssp. *borealis*, showing its thick long root. This specimen was growing in deep sand on the lower slopes of a hill where the root could grow straight. Plants at this location were very drought stressed. The ruler is 100 mm long.
- ◀ A large plant of *C. megarhiza* ssp. *borealis*, growing in its core area in the Sierra Pinuno. Here, there is a noticeable variation in growth form (see pages ????)
- ▼ *C. megarhiza* ssp. *borealis* in flower. This plant, grwoong in the Sierra Pinuno, has recently had rain and the body if fully pumped up.



Endnotes for chapter ?

Ocean rocks well above high tide, p 149

It is common along the north Chile coastline to find stranded ocean boulders up to 15 m above the high tide line. In some cases, these are 100 m inland in areas that are now well vegetated. The presence of these boulders demonstrate the rate at which the continental plate is being uplifted (up to 10 mm per year). The new land is (or at least was) an ideal place for copiapos to colonize. *C. coquimbiana* and *C. haseltoniana* both are often found in such environments.

Damage done by donkeys

Donkeys, which are introduced animals and most of which are now feral, are much more destructive of the environment than the native guanaco. Donkeys have large hooves which are used rather sloppily, kicking loose rocks and scuffing against the soil. Guanaco paths are narrow and neat, the animals normally move slowly, carefully picking their way between loose rocks to find firm ground. They travel silently on the hillsides, unlike donkeys which can be heard long distances from the sound of the tumbling rocks they send flying when they walk. As a result, paths which have been used for tens of thousands of years by guanaco are being destroyed by donkeys. Often whole hillsides, with highly fragmented rocks, are churned up and destroyed by a slow avalanche of loose rocks tumbling downhill. Established copiapos can tolerate this but it will be virtually impossible for new generations to establish themselves in such an unstable surface.

echinata, *megarhiza*, page 47

Current thinking places *C. echinata* as a variety of *C. megarhiza*, which I do not agree with. The main criterion seems to be that both species have a thickened taproot, a characteristic shared by many other species. Another is that both species are spiny. Again, not unique. Lastly, both taxa are somewhat connected by *C. megarhiza* ssp. *borealis*, which is the coastal form of *megarhiza*, having thinner spines and smaller bodies. Using the above criteria, it is just a logical to include *C. echinata* in with the *C. coquimbiana* complex, especially when some of the larger plants are considered, which can have up to 100 heads and be 1m in diameter. Because of this, I recommend that *C. echinata* be considered a separate species.

Finding a single 'new plant' means what?

Every visitor to habitat has the hope that they will find something new. And they do, but it will invariably be a variant of the common. Consider the photos on page ??? All were taken on a single morning's walk among a *C. megarhiza* ssp. *borealis* population on Cerro Chascón in the Sierra Pinuno. Looking at only these variants, the question of how many species grow on this hill is a valid one. Looking at the whole population and its diversity, the answer is only one. Be wary of making something special from only one unique plant in habitat, it will invariably be an aberrant form of whatever else is nearby.

Shore versus mountain dwelling species

Early in my travels examining copiapos, I was of the belief that some species were mountain dwellers (core areas above 500 m) while others were coastal species. The more exploration done, the more we find that the supposed coastal species (such as *C. dealbata*), are actually mountain species, with its core area high in the mountains at over 700 m. At present, Only *C. echinata*, *C. albispina*, *C. ahremephiana* and *C. longistaminea* are essentially coastal, however each of these has its healthiest plants near the upper elevational limits.

(1) The plans for a coastal road.....

Copiapoas Chañaral to Caldera

Copiapoa calderana

Copiapoa chanaralensis

Copiapoa cinerascens (southern form)

Copiapoa hypogaea

Copiapoa marginata

Copiapoa humilis var. 'Leonensis'

Copiapoa megarhiza. ssp. 'Quebradesa'

Chañaral to Caldera

Chañaral (27° 40'S) sits at the mouth of a long, wide valley which cuts through the coastal hills. While the valley appears to be a major barrier to copiapoa distribution, most species from the north and south have distributions which cross the valley. Caldera, which is at the southern edge of the sector, is some 100 km from Chañaral. Just south of Caldera is the large wide valley of the Copiapó river. This river carries year round snow melt water from the Andes and is a natural division between copiapoa habitats.

The hills between Chañaral and Caldera are not as steep as those immediately to the north but they are higher. The coastal hills range from 300 m up to 600 m with some more inland hills reaching over 1400 m. The shallower gradient of the coastal hills allows the fog and mists to penetrate further inland than in most areas of the north, resulting in copiapoa habitats extending more to the inland. Several deep valleys cut through the hills and provide access to the interior.

The climate between Chañaral to Caldera is similar to the more northerly sectors. The area is still too far north to receive regular winter rain⁽¹⁾. Fog is heavy on the hills, especially so on the southern hills just north of Caldera where several southwest facing valleys have well

▼ The Quebrada Infieles cuts through the low hills just south of Chañaral. In this valley there are *C. hypogaea*, *C. cinerascens* (southern form), *C. marginata* and *C. chanaralensis*. The furthest inland copiapoa are about 10 km from the sea.



developed vegetation at the higher, fog shrouded, elevations. The Chañaral valley on the other hand, is very dry from its mouth right up to higher elevations because of the blocking effect of the coastal mountains which intercept the moisture laden winds coming in from the southwest. The true desert (where no cactus of any species can survive) varies from 5-20 km inland, depending on the gradient and on the elevation of the hills. Where high hills block inland movement of cloud, the desert extends close to the coast. Where the gradient is gentle, plants grow further inland. In some areas near deep valleys, vegetation extends over 20 km inland, with *Euphorbia lactiflua* (an indicator of the presence of fog) extending up to 1200 m elevation.

Some of the coastal plains are poorly vegetated because of their dryness. This is especially evident near Caldera. Here, the coastal plain is wide, extending several kilometers inland. The closer to the coast, the barer the vegetation

Associated organisms

Deuterocohnia chrysantha is still important, especially on the coastal slopes. Most plants are now dead. *Eulychnia brevifolia* populations are healthier than further north. Several wet oasis, such as Quebrada Hormiga and Quebrada El leon, have environments which are heavily vegetated with *Eulychnia brevifolia*, *Oxalis gigantea*, *Euphorbia lactiflua*, *Trichocereus deserticola* (now becoming rare) and other associated fog

▼ *C. marginata*, growing on granite hills (inland from Flamenco, looking south). Wide valleys cut through the coastal mountains in several places in this sector. The hills are not as steep or as high as in the northern sectors.

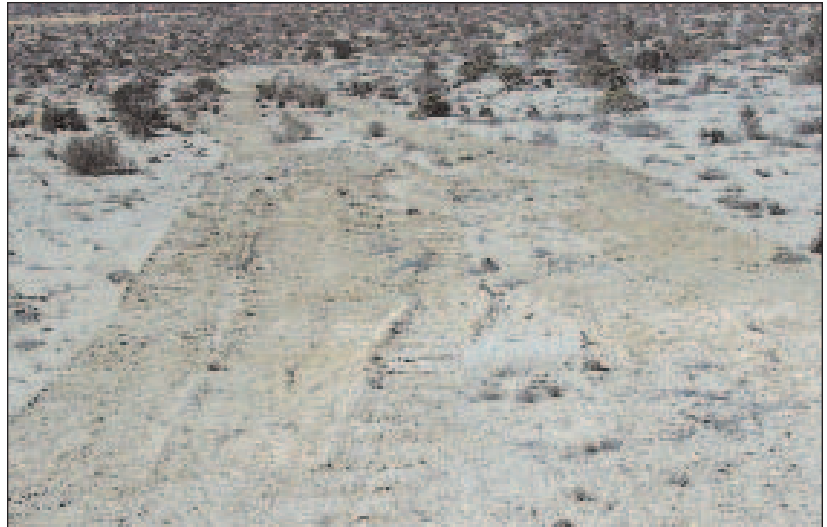


shrubs. In the most favorable areas, the head height shrubs are close enough to touch, forming miniature forests. *Eriosyce rodentiophila*, *E. taltalensis* (several forms) and *E. krausii* grow within the sector however the later is seldom found unless in flower as it retreats underground for most of the year.

Mammals are much more common than further north with donkeys and guanaco being very common. Goats are kept in some of the wetter valleys north of Caldera and have done significant damage in the limited areas which they graze. Guanaco and donkeys are present but not in as great a number as in the Pan de Azucar park (just north of Chañaral) or further south. Small scale mining still takes place in this sector and it may be that the miners shoot the occasional unwary guanaco.

Man's influence is significant as a result of the numerous summer beach houses which have sprung up along the coast. During summer, adventure seeking beach growers often drive up the valleys and signs of damage to copiapos are not uncommon. No significant active mining activity occurs in the copiapoa habitats however the numerous old mines and prospects suggest that with higher copper prices, mining could again become active. Sadly, road building has taken the greatest toll on copiapoa habitat with large areas being cleared completely of vegetation when roads are widened or bridges replaced. It is not so much the roadside damage, rather, the off-road areas that are cleared for the storage of machinery. Several years ago two bypasses were constructed through the *C. calderana* 'Atacamensis' habitat, resulting in thousands of plants being bulldozed. Today however, these two now abandoned bypasses offer a convenient place to pull off of the highway to view plants.

Road building damage north of Caldera, four years after the event. So far, no new plants have colonized the damaged areas.



Chañaral
 Caldera
 Quebrada Infieles
 Flamenco
 Quebrada Hormiga
 Quebrada El leon
 Quebrada del Morado
 Barquito
 Quebrada Los Inieles
 Quebrada Animas
 Viejes
 Cerro Copiapó
 Quebrada Aspera

Copiapoa distribution

Copiapoas extend in an almost continuous band from Chañaral to within 10 km of Caldera. South of this, the dry, flat marine terrace and low hills no longer support live plants, except on a few isolated hillside refuges.

Seven species of copiapoa occur in this sector, these being *C. calderana* (two forms), which form extensive populations on the coastal plains and the lower slopes of the hills along much of this sector. *C. marginata* grows higher on the coastal hills and extends inland up to 20 km along the larger dry river valleys. It may have a very wide distribution throughout the coastal hills but lack of access prevents verification of this assumption. *C. hypogaea* grows on the higher coastal hillsides from Obisito north to Chañaral. It favors the foggy and windy ridges. It can extend 10 km inland along the rims of the dry river valleys, especially on hilltops and ridges which have unhindered access to the southwest. *C. cinerascens* extends south from Chañaral only as far as Flamenco. Near Chañaral it grows along the coastal plains, further south, it prefers the coastal hills and the interior valley slopes. *C. chanaralensis* prefers the interior hills near the edge of the true desert. It has only been found southwest of Chañaral but may be much more widespread. *C. megarhiza* 'Quebradesa' grows east of Caldera in the interior hills and valleys. *C. humilis* 'Leonensis' is found just north of Caldera, growing from lower slopes of the coastal hills up onto the ridges some 12 km inland. Northern species which do not extend as far south are *C. columna-alba* and *C. serpentisulcata*, which occur on the hills just north of Chañaral, and *C. grandiflora*, which grows to within 20 k of Chañaral. Two southern species, *C. echinoides* and *C. echinata* reaches to within 20 k of Caldera.



▲ *C. calderana*, growing in a protected location where its wool and spines remain unstained.

▼ The typical habitat for *C. calderana* (green form). Most plants grow on the coastal terraces within sight of the sea. The plant in the foreground is unusually large. Most plants of this age and size have died, leaving only single headed plants which are often wider than they are high. The thick stemmed shrubs are *Euphorbia lactiflua* in their dormant leafless stage.

C. calderana

Ritter's *C. calderana* has a green body free from silvery wax (the *C. lembckeii* of cultivation). Plants are usually found as single headed individuals up to 300 mm tall however in the most favorable sites they can form clumps of up to ten heads. Plants have a swollen tap-root and can re-grow new stems if these are damaged or knocked off. Generally, populations are found under 300 m elevation and within sight of the sea. The more arid and stressed the environment, the shorter and more likely plants are to be singled headed and heavily spined. The largest plants grow at 200 m elevation near the base of hills in the southern part of its range. The remains of larger plants are not uncommon today at other sites but as a general rule, the larger plants have mostly died in all but the most favorable habitats.

In its northern and inland forms, *C. calderana* is often difficult to delineate since it hybridizes and forms transitions with *C. marginata* (inland) and with *C. cinerascens* (along the coastal terraces).

Along the southern and central coast, the green bodied *C. calderana* is the only copiapoa to be seen for a 50 km long stretch except for the occurrence of the white wax covered form 'Atacamensis', which forms a small but dense population for 5 km along the coast and nearby coastal hillsides. *Copiapoa calderana* (white form) has a



completely different growth form than the smaller, usually single headed *C. calderana*. It forms clumps of up to fifty heads, some of which reach lengths of almost 1m. Stems are usually elongated but some plants form compact clumps. At the southern edges of its distribution the silver bodied plants form a transition zone with the smaller, green form *C. calderana*. To the north, the Quebrada del Morado forms the edge of northern distribution of *Copiapoa calderana* 'Atacamensis'

The relationship between *Copiapoa calderana* 'Atacamensis' and the green form of the species is confusing⁽²⁾. Ritter makes no mention of a silver bodied copiapoa coming from this area, however some of his later collections and introductions into cultivation include mention of white bodied *C. calderana*. Hoffman (1989) named the white bodied plant *C. calderana* while completely ignoring the green bodied form which dominates most of the coastal habitat. She combined the silver bodied plant with *C. atacamensis* from the far north and it is easy to see why this association was made. Both plants look very similar. Recent IOS work has recommended that *C. atacamensis* be combined with *C. calderana* (both forms?) which is quite acceptable however it does not explain or discuss the issue of the relationship of the smaller green *C. calderana* with *C. calderana* 'Atacamensis'.

Ritter found a slightly different population of *C. calderana* grow-



▲ A mature *C. calderana* showing typical epidermis colour, shape and rib count.

▼ The single stemmed plant on the upper left is most likely a re-sprout from a larger, mature plant, the remains of which is now just spines. Investigations of dead copiapoa remains indicate that they decay slowly. These old spines may be many decades old.





▲ A compact specimen of *C. calderana* ssp. 'atacamensis'. The stems elongate with age and can reach 1m in length.

▲ A single headed *C. calderana* 'Atacamensis'. Compare this to page ???.

▼ The habitat of *C. calderana* 'atacamensis'. Plants also grow to the tops of the hills in the background.



ing 20 km south of Chañaral on low, coastal hills. This he named ssp. *spinosior* because of its longer spines than those on the typical green bodied *C. calderana*. In sheltered locations such as among large boulders the spines are golden in colour because they are not exposed to direct fog and therefore cannot support the humid loving algae and fungus associations on and in the spines. On more exposed inland and higher elevations, ssp. 'spinosior' grows larger but tends not to have clean, golden colored spines.

It is unknown why the white wax covered *C. calderana* is so much healthier than the green form. It is doubtful if soil or any environmental factor is responsible because the two forms grow so close together and still show dramatic differences in size and vigour. While the white wax covering may be an advantage, it is doubtful if this one difference can be used to explain the difference in growth.

The core area (see map page ??) of the green form of *C. calderana* is difficult to establish but the largest and healthiest plants are in the more southern part of its range growing at around 200 m on west facing slopes. *C. calderana* is typically the only copiapoa species in its habitat, however occasionally it grows with *C. humilis* 'Leonensis' and in its southern range, *C. megarhiza* 'Quebradesa'.

C. calderana is endangered from the continued drought. The southernmost plants are dying out rather quickly. Charles (1998) mentions that *C. calderana* extends to within 8 km of Caldera but



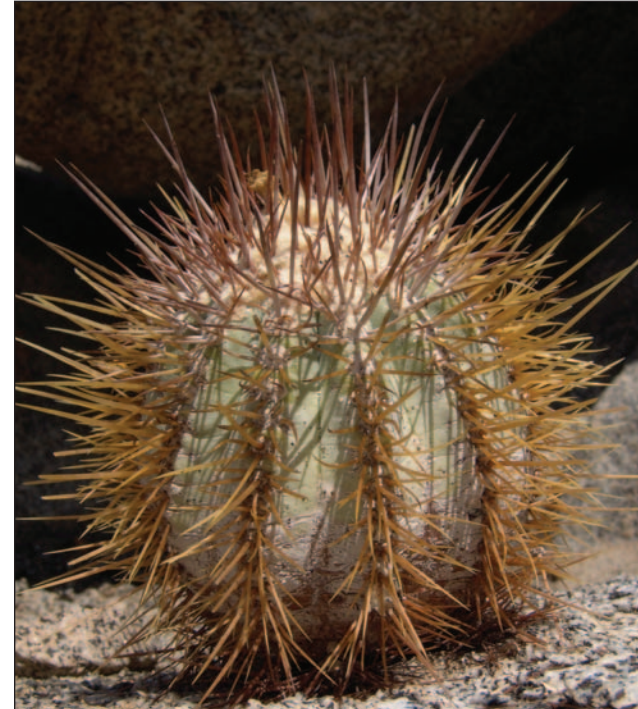
today this area appears to no longer have living plants. The southern-most plants that I know of now grow some 13 km north of Caldera. All the plants growing on the coastal terraces are suffering from drought, with many more dead plants visible than live ones. Plants growing higher up on the coastal hills are faring better however most of the larger, multi-headed examples are dying, leading new visitors to its habitat to conclude that this species is single headed at maturity.



▲ *C. calderana* 'Atacamensis'

■ A large plant of *C. calderana* 'Atacamensis' growing among granite rocks on the coastal terrace north of Caldera.

▼ *C. calderana* 'Spiniosior', a name Ritter coined for longer and golden spined population growing 20 km south of Chañaral. Plants grow sheltered among large granite boulders.





▲ *C. chanaralensis*, during the dry winter of 2004.

▼ *C. chanaralensis*. This plant is about life size and typical for the mature plants we found.

C. chanaralensis

This species is characterized by its small hard green body which is without wax. *C. chanaralensis* has a limited range, extending only about 20 km south of Chañaral, always away from the coast at elevations above 500 m. Ritter, who described the species in 1980, was quite precise when giving the location for the habitat of this species, recording it growing inland at the edge of the true desert south of Chañaral. He also mentions that it grows inland from *C. cinerascens* populations, which extends to at least 450 m in elevation along several valleys south of Chañaral. The two species do not grow together.

The easiest to reach plants is in the upper reaches of the Quebrada Infieles which enters the ocean some 10 km south of Chañaral. This gently sloping valley is long, extending into the true desert. We found our first *C. chanaralensis* growing at 500 m in elevation up to at least 800 m. The first plants encountered when walking up the valley are 9 km inland from the coast. Everywhere, plants remain small, being mostly single headed. There were signs of larger stems but these have all been knocked off or destroyed by guanaco and donkeys trying to get to the thick tap root. The spines are strong, giving some protection from predation but the narrow neck of the root/stem connection is weak and breaks easily. Plants with healthy



roots will normally re-grow new heads quickly.

Ritter's *C. chanaralensis* appears to be unrelated to the nearby *C. cinerascens*. It grows far from *C. calderana*, which is a more coastal species. At one location, *C. chanaralensis* grows with *C. marginata*, from which it is easily differentiated in adult form, however, young plants can look similar.

The core area (see map, page ??) of *C. chanaralensis* is high up in the inland hills above 700 m. Even here, there are more dead plants than living ones. Guanaco and donkeys knock off heads in an attempt to get at the swollen root but this is usually unsuccessful and the plants grow back new, but progressively smaller heads. It is difficult to determine how large *C. chanaralensis* can grow since all of the fully mature stems appear to have been destroyed, however, an examination of dead remains shows stems which would have reached 200 mm in height.

The name *C. chanaralensis* appears to have been incorrectly used for intermediate populations of *C. calderana/cinerascens* which grow on the coastal terraces just south of Chañaral. Such plants are quite different from the inland plants shown here and are clearly not the *C. chanaralensis* described by Ritter as coming inland from near the edge of the true desert. The CCG has unfortunately decided that *C. chanaralensis* is a form of *C. humilis*. I can only assume this is based on an assessment made from incorrectly labeled cultivated plants since it is obvious that the plants from Ritter's locality are not closely related to *C. humilis*.



▲ Typical habitat of *C. chanaralensis*.

▢ Close-up (slightly larger than life size) of the plant pictured above.

▼ The root of *C. chanaralensis* is thick and has a narrow neck where it meets the stem. Dislodged stems were common, indicating that guanacos and donkeys were trying to feed on the roots.





- ▲ This *C. cinerascens* has fewer and thinner spines than typical plants from north of Chañaral.
- ▼ Spine length and colour can vary on the same plant. This is largely due to exposure to fog and sun.

C. cinerascens (southern form)

The presence of large and impressive population of *C. cinerascens* south of Chañaral has seldom been commented on, most likely because these populations occur far from the coastal road and require a detour on rough roads to reach. Ritter's variety *intermedia* applies best to be the inland form. *C. cinerascens* ssp. *cinerascens* is said to occur along the coastal terraces just south of Barquito and extends 30 km further south. Both forms hybridize with *C. calderana*. This is most obvious along the coastal terraces just south of Chañaral.

C. cinerascens, while strictly a coastal species north of Chañaral, becomes an inland species to the south. The lower elevation (150-250 m elevation) populations are suffering severely, with only single headed or small clumps remaining. At 250-400 m in elevation, the plants increase in size and health with some specimens reaching 1m in diameter. This inland form of *C. cinerascens* differs from the well known northern form from near Pan de Azucar by being spinier and



having smaller heads. The best specimens grow on sheltered cliffs where then get some shade in the afternoon. Those plants on north facing slopes are suffering from drought related stress far more than those plants growing in more sheltered positions. As a general rule, the further inland, the spinnier the plant.

The core area for *C. cinerascens* south of Chañaral is in the Quebrada Los Inieles and Quebrada Animas Viejes at elevations of 400-500 m. Plants vary between these quebradas, mainly in spination and body colour. *C. cinerascens* on the coastal terraces are often small and single headed and can flower when only 30 mm in diameter. They generally have 14-18 ribs while the neighboring *C calderana* generally have more than twenty ribs. The healthiest *C. cinerascens* grow on rocky sites facing northeast with some protection from the



▲ This *C. cinerascens* has more spines than most and also has a more developed white wax layer on the epidermis.

◀ A very large plant of *C. cinerascens* growing about 20 km south of Chañaral. This plant was growing at 250 m in elevation, which was at the lower end of the elevational range for the southern form of this species. The dark mounds on the hillsides in the background are dead clumps of *Deuterocohnia chrysantha*.



▲ A single headed *C. cinerascens*, growing 40 km south of Chañaral. Plants can flower when only 30 mm in diameter.

▶▶ Three(?) plants of *C. cinerascens*. The lighter colored smaller stem in the middle may be a new stem growing out from the larger plant. The variation between plants seen in this picture was typical for this habitat.

C. cinerascens (southern form) continued....

afternoon sun. This is contrary to the normal situation where the northwest slope is preferential, suggesting that drought stress has adversely affected plants on the sunniest sites .

C. cinerascens is endangered in the area south of Chañaral, particularly at lower elevations where most of the larger plants have died. Single headed examples, particularly those which grow partially retracted in loose rubble, still look healthy. There are no signs of seedlings having survived from recent decades.



C. hypogaea

C. hypogaea is characterized by its small, soft body which is usually weakly spined and often grows level with the ground. Populations vary greatly within and between themselves⁽³⁾.

C. hypogaea grow mostly along the tops of the coastal hills at elevations of 300-600 m. In the south, plants extend from at least 26°38'S (60 km north of Caldera) north to the hills near Esmeralda (40 km north of Chañaral). There are reports that it also grows in the Copiapoó valley. While the great majority of plants grow within sight of the sea, some small populations occur further inland on ridges and saddles where fog penetrates and lingers. In an extreme case, a small population of *C. hypogaea* was found at the edge of the desert some 40 km from the sea at an elevation of 450 m. Here, the plants were larger and harder bodied (see photo, page ?? that the coastal form. The body texture (see photo, page ??) of this inland form most closely resembles the popular form grown in cultivation however in habitat it is very rare.

The habitat of *C. hypogaea* varies. Most plants in the Chañaral to Caldera sector grow in rock crevices or at the base of large rocks where they are protected from guanaco and donkey digging. Some



▲ A stressed plant of *C. hypogaea* growing on a coastal ridge top just south of Flamenco.

▼ A typical habitat for *C. hypogaea*. These hill tops are usually fog enshrouded for much of the day. The highest concentrations of *C. hypogaea* are near the tops of such hills.





▲ *C. hypogaea* is a variable species. The spiniest plants come from north of Chañaral.



- ▲ An inland from from Quebrada Animas Viejas.
- ▶ A nearly spineless plant from north of Chañaral. Note the flower bud on the upper stem.
- ▼ *C. hypogaea* var *barquitensis*. This variety shows the least variation within the species.



C. hypogaea continued....

plants grow in soft rubble or on decomposed granite but most of these plants have been destroyed by guanaco and donkeys. It is frequent to find the dried remains of chewed *C. hypogaea* heads in such habitats.

Variation within the species is most obvious when observing spination, which can vary from none to quite spiny. Body texture, size, colour and firmness of body also vary, often within plants growing only a few meters away. The variation within a population is often as great as that between populations.

Ritter's *C. hypogaea* var. *barquitensis* grows in the hills above Barquito. Unexpectedly, plants were not growing on north of north-west facing slopes but rather on east and south facing ones where more shade is available. Plants grow in a small but dense population and are surprisingly consistent in texture and spination when compared with *C. hypogaea* plants further north and south. Like other *C. hypogaea*, variety *barquitensis* has a contractile root, retracting the heads at or below the soil level during dry periods. When grown in loose rubble or decomposed granite the plants can be partially buried for most of the year, only emerging briefly when fully swollen with water after a soaking rain.



C. hypogaea seems to flower seasonally (around November) or in response to soaking rain. It is very unusual to find a plant with a fruit of bud during winter.

The core area of *C. hypogaea* cannot be discerned, mainly because most populations grow only in a narrow, (often only 150 m wide) band which extends along the coastal ridges. The two densest populations grow in the hills above Barquito (variety *barquitensis*) and north of Chañaral in the Los Lomitas area of the Pan de Azucar Park.

C. hypogaea is endangered from guanaco and donkey predation throughout its range⁽⁴⁾. I have never found young growing in any of the diverse habitats visited. Because of the low numbers of individuals, collecting of plants by growers is also a problem. Luckily, none of the populations are easily accessible with many being difficult to reach.



▲ *C. hypogaea* ssp. *barquitensis* typically grows among large rocks where it is protected from guanaco and donkey damage.



◀ An old plant of *C. hypogaea* with strong spination (footnote 1). This plant, from south of Flamenco, was growing near weak spined plants.

▼ On some interior hills, a few *C. hypogaea* still hang on as isolated plants in deep rock crevices. Their bodies are firmer than the coastal form. The skin texture is wrinkled and similar to a form common in cultivation.



C. marginata

C. marginata is extremely variable between populations. The green stems are hard bodied and the ribs are distinct and deep. Stems elongate and can be up to 800 mm long, forming clumps to over 1 m in diameter. Flowering and fruit production appears to be seasonal or rain event triggered. Old dried flowers were abundant but it is not possible to determine how old these are so it is unknown if flowering occurs in a short period of time or is spread out over many months. In general color and appearance, *C. marginata* resembles some forms of *C. rupestris*, *C. coquimbana* and *C. echinoides*. From a 'lumpers' point of view, it may be a good idea to consider these four species as belonging to the same complex if not the same species. Aside from the green color of the epidermis, it also shows growth similarities with *C. atacamensis*, especially those plants which grow in a similar windy and foggy site such as on top of Morro Moreno (near Antofagasta).

▲ *C. marginata*, growing on Cerro Copiapó. Note how the spines on the western side (right) are lichen encrusted.

Copiapoa marginata is often thought of as being a coastal dwelling species which grows in its densest numbers and largest size just



below the fog zone. It is recorded from just north of Pan de Azucar (as *C. marginata* 'Bridgesii') to Morro Copiapó which lies just south of the town of Caldera. Morro Copiapó is a very accessible and often visited hill which appears to be the southernmost location for this species⁽⁵⁾. Cerro Copiapó only reaches 343 m in height, which is at the lower limit of the fog layer. This population is a relict of a wetter and foggier time when the species would have been more widespread. Additional widespread and dense populations are found north all the way to nearly Barquito.

On Cerro Copiapó, *C. marginata* grows among rocks and boulders. A small area of sandy soil on a near flat slope had no copia-poas suggesting that rocky ground may be necessary for successful seedling establishment. *C. marginata* occasionally grows with *Eulchnia brevifolia* which on Morro Copiapó grows as a wide and sprawling 1 m tall shrub. Several old *E. brevifolia* had single headed *C. marginata* growing from near their now dead centers, suggesting that clumps can provide suitable conditions for *Copiapoa* seedling survival. Several low, perennial shrubs also share the top of Morro Copiapó with *C. marginata* and signs of annual growth were also abundant.

C. marginata it grows through the mountains behind Chañaral in an almost continuous band down to Morro Copiapó. Plants grow best at mid elevations of 500-800 m however some plants descent closer to sea level at near Flamenco and Q. El Leon. The lower elevation plants are generally stressed, often the older stems have died and only a few short re-growth stems remaining on their enlarged tap root. Surprisingly, plants were found growing 21 km inland (from Flamenco) at an elevation of almost 1400 m. These mountain forms of *C. marginata* are much stronger spined and squatter than the leggy coastal plants.

Throughout most of its wide and diverse distribution, the overall health of *C. marginata* appears to be good, with plants of all sizes being evident. Small plants under 75 mm were scarce but those found were in good condition. Dying plants were usually old and had elongated stems and an open growth habit. Dead clumps also often showed more stem elongation than most living clumps which tended to have shorter stems and form more spherical shaped mounds.

Only two forms of *C. marginata* are well known in cultivation. Both happen to be the geographical extremes for the species. Those from Morro Copiapó represent the southernmost examples of the species while *C. marginata* 'Bridgesii' is the northernmost. It is quite understandable that many collectors prefer to give different names to these two forms considering how different they look. When all the intermediate forms growing in the mountains in between the two



▲ *C. marginata* growing near the top of Morro Copiapó. Note how the growth form varies from open (on left) to compact. Compact plants are

▼ *C. marginata*, growing at the base of Morro Copiapó. Most plants grow near the top of the hill but this plant has found a favorable situation at the base of a large boulder. The green hillside is in response to good winter rains.





▲ One of the many forms of *C. marginata*.

▼ A large *C. marginata* growing at 1350 m about 21 km inland from Flamenco. Plants growing at higher elevations were almost all dead.

extremes are considered the differences become less dramatic. It is unfortunate that these intermediate forms are seldom seen in collections, especially considering how abundant and widespread they are. The high elevation forms of *C. marginata* are very different from either the northern *C. marginata* 'Bridgesii' or the southern Cerro Copiapó forms, often being as spiny as *C. megarhiza*. Ritter believed that *C. marginata* was related to *C. megarhiza* which is easy to accept once the mountain forms are considered. *C. marginata* comes within 20 km of the most northwest population of *C. megarhiza*, further explorations in the region may lead to the discovery of a transitional population. It grows and readily hybridizes with *C. megarhiza* 'Quebradesa' in the southernmost tributaries of Quebrada del Morado.

The core area for *C. marginata* appears to be high in the north-west facing mountain slopes inland from Flamenco. Plants grow at their largest and healthiest at around 900 m. Easy access to the mountains is very limited so further populations of equal size may be present to the north or south of Flamenco.

C. marginata is not endangered as a species. The northernmost *C. marginata* ssp. 'Bridgesii' form would be the most endangered, with many of the mature plants now dead from drought, including even those in the core area at 500-600 m elevation. South of Chañaral,



many of the older plants of *C. marginata* growing at lower elevations are dying, however the higher elevation plants are surviving better. True seedlings have never been found and small plants always turn out to be re-sprouts from older plants which have had their main stems knocked off. As with other multi-stemmed species, those *C. marginata* with short stems and a tight offsetting growth are surviving the dry conditions better than floppy, long stemmed plants.

C. marginata appears to readily hybridize with *C. calderana*. The plants form transitional populations wherever they meet. Inland from Flamenco in Quebrada Aspera there is a large transitional population growing on low hills inland and out of sight from the coast. Ritter (1980) commented on this population and described the plants as looking more like the illustration of *C. echinoides* (which Ritter did not recognize as a distinct species) in Britton and Rose (vol 3, p 88). *C. marginata* also hybridizes with *C. cinerascens* at mid-elevations towards Chañaral. It also appears to hybridize with *C. chanaralensis* at one location where both species grow together. *C. marginata* also hybridizes with *C. cinerascens* at mid-elevations towards Chañaral.



- ▲ A small and stressed *C. marginata* growing at high elevations. The spines have been bleached from the intense sunlight. There is no sign of new growth.
- ◀ A high elevation *C. marginata*. Note the new spine growth, most likely as a result of the rains of 2002.
- ▼ Older plants of *C. marginata* typically have elongated stems.





▲ This stem of *C. megarhiza* 'Quebradesa' an immature re-sprout (see photo next page of young stem). It shows much more of the body as well as having new spines.

▼ A fully mature *C. megarhiza* 'Quebradesa'. This plant was growing at 800 m elevation.

C. megarhiza 'Quebradesa'

First found growing on the higher hills north and east of Caldera, this variable taxon is difficult to classify with anything other than *C. megarhiza*. It appears that Ritter was unaware of this plant and it was also not mentioned by Meregalli & Doni (1991), Hoffmann (1989) or Charles (1989). Plants are heavily spined, grow from an enlarged taproot with a narrow stem neck and generally form clumps of up to only five stems. The area of this plants range has been poorly explored so populations may exist which form larger clumps.

The nearest *C. megarhiza* to the habitat of 'Quebradesa' is *C. megarhiza* ssp. *borialis*, which grows just south of the Rio Copiapó some 20 km away. *C. megarhiza* 'Quebradesa' differs from this variety by having fewer stems and a greener body, even in stressed situations. At higher elevations, stressed plants resemble *C. echinata*, but only because so little of the body is evident. The number and thickness of spines, as well as the number of heads per plant, increases with elevation. Very stressed plants at low elevations have thin spines and can be partially buried in the ground. Plants grow mainly on more or less flat ground or on north facing slopes. At lower elevations they grow with *C. marginata* and a few *C. humilis* 'Leonensis' which is the only



other copiapo species which grows in the area.

The distribution of this taxon is limited to the hills north and east of Caldera. It appears not to grow very far to the north but does grow on some very dry low hills immediately east of Caldera at elevations of 200-300 m, where it is the only copiapo species.

The core area of *C. megarhiza* 'Quebradesa' is in the coastal hills above 600 m in the Quebrada El Leon and Quebrada La Hormiga. The plants are faring well, with few dead plants visible. Multiheaded plants are only common at elevations above 600 m. The highest elevation plants located were just under 1000 m. Because of the inaccessibility of the area, the distribution of *C. megarhiza* 'Quebradesa' may be much more extensive to the north than now known. The plant does not appear to be endangered in any part of its range. At the inland part of its range near the deserts edge, *C. megarhiza* 'Quebradesa' hybridizes with a small growing form of *C. marginata*.



C. megarhiza 'Quebradesa', growing at 600 m elevation. This plant showed more of the body than most plants at higher altitude.

The habitat of *C. megarhiza* 'Quebradesa'. The largest concentrations of plants were growing on top of the ridges or on north facing slopes.

Two young stems have grown from this swollen root once the original stem had been knocked off by guanaco or donkeys. Each is 20 mm in diameter.





▲ *C. humilis* 'Leonensis', growing at 400 m.

▼ *C. humilis* 'Leonensis', growing at 900 m. This high elevation form has much longer and thicker spines than plants growing close to the coast in the fog zone.

(Insert): Newly emerged bud showing juvenile characteristics.

C. humilis 'Leonensis'

Recently, a population of copiapoas was found which most closely resembles *C. humilis*. Plants are generally single stemmed and seldom grow higher than they are wide. The body is slightly soft, especially so on plants growing at the lower elevations of its range. The taproot is large with a narrow neck. New shoots growing from roots which have had their stems knocked off appear bristly. The spination is similar to *C. humilis*, with plants growing at higher elevations having much thicker spines than plants at the lowest elevations. High elevation plants differ from more coastal ones by having a visible wax coating, making the epidermis appear slightly whitish. The spine coloration of high elevation plants is also much lighter than those growing in the fog zone.

C. humilis 'Leonensis' grows from about 200 m up to 1000 m on the most fog bound hillsides between Quebrada de Leon and Quebrada La Hermiga. They are mostly found on northerly facing slopes. Isolated plants have been found further north and south. The core population is in the foggiest southwest hillsides at 400-500 m elevation. The highest elevation plants grow above the normal level of fog but do not extend to the edge of the true desert. In the fog zone,



plants grow among dense *Euphorbia lactiflua*, *Oxalis gigantea* and other shrubs.

This form of *C. humilis* extends the range for this species and connects up the very discontinuous distribution pattern for this species, which grows from 24°N down to 29°N, a distance of some 440 km. There may be more populations of *C. humilis* in the Chañaral to Caldera sector but because of the lack of exploration and the difficulty of access, they have not yet been found.

C. humilis 'Leonensis' has been found growing with *C. calderana*, *C. marginata* and *C. megarhiza* 'Quebradesa'. No hybrids have yet been located.



C. humilis 'Leonensis' at La Hermiga. Flowers were present during winter on occasional plants.

C. humilis 'Leonensis', growing at the base of a large granitic boulder. Note the heavy lichen growth on the eulychnias, indicating that this habitat is within a heavy fog area.

Habitat of *C. humilis* 'Leonensis'. At this location, it is the only copiapoa species



Endnotes for chapter ?

(1) During late August of 2005, an intense band of rain and cold mountain air resulted in snow down to 1200 m in the Caldera and Copiapó area. The event was not something that locals could remember happening in their lifetime. Perhaps this weather is a one in a hundred year event but as far as copiapoa distribution goes, it may explain why plants do not apparently grow above about 1400 m.

(2) There are several possibilities for dealing with the confusing taxonomic complexity of *C. calderana*. The easiest is to consider the small, mostly single headed green bodied plants the same as the larger, clumping silver bodied plants. Since both plants form transition zones it is logical to consider them to be one species. Difficulties come if the presence of transitional populations becomes the main criteria for considering the delineation of a species because *C. calderana* also forms transitions with *C. marginata* and *C. cinerascens*. Taking this logic further, it would mean that all the above mentioned taxa would have to be considered as forms of *C. marginata*. I would argue that *C. calderana* is quite separate from *C. marginata* and *C. cinerascens*. The other option is to consider the two forms as separate taxa with the larger white form possibly being a successful mutation arising relatively recently from the typical green form

(3) Like many copiapoa, *C. hypogaea* exhibits dramatic differences between juvenile and adult growth forms. Stems which have grown from a seed and have not been dislodged and replaced from the swollen taproot, are usually quite spiny and elongated (photo ??). Plants which are re-growths from the taproot take on a flatter and less spiny appearance. When I first found such elongated, spiny plants (which are also often growing hidden inside bushes or in deep rock crevices), I assumed they were something different but the numerous transitional forms show that they are all just forms of a variable species. I am also sure that some of the propensity to spininess is genetic but how much is difficult to determine. Seedling observations should help but seed from habitat *C. hypogaea* is almost never found so this will be a difficult project to undertake.

(4) In habitat, the pattern of eaten and uneaten *C. hypogaea* is unusual. In many areas some plants are eaten, while some plants are not. The question of how guanaco detect plants is intriguing. The options are that they are picked out by sight, by smell or by touch, or by a combination of these. The sight option is the least satisfactory, as often obvious prominent plants are not eaten. The smell option also has problems, as it does not explain why all the plants are not eaten (unless some smell less than others, which seems unlikely). Ingrid Schaub proposed that guanaco become aware of *C. hypogaea* mostly by treading on them and feeling the small spines or the squishy body. If this is so, it explains the many footprints in some areas where plants have been eaten. It also explains the occasional missed plants, which are sometimes quite obvious to sight.

(5) The *C. marginata* population from Morro Copiapó is believed to be the type locality for the species but there is no evidence that the original collector (Philippi, 1836?) collected it from here. In those days, localities were very vague so later explorers, in this case Dr. Rose (USA), would have collected it from the most likely locality, that being Morro Copiapó. For many years, this was believed to be the only locality for the species, however a walk up into just about any of the coastal hills between Caldera and Chañaral should turn up populations of *C. marginata*.

Copiapoas: Taltal to Chañaral

Copiapoa cinerascens
Copiapoa cinerea ssp. *columna-alba*
Copiapoa grandiflora
Copiapoa laui
Copiapoa longistaminea
Copiapoa marginata 'Bridgesii'
Copiapoa mollicula
Copiapoa rupestris ssp. *rupestris*
Copiapoa rupestris ssp. *desertorum*
Copiapoa rupestris 'Aphanes'
Copiapoa serpentisulcata
Copiapoa taltalensis (*C. hornilloensis*)
Copiapoa sp 'Guanillos'

►► Taltal as seen from the top of Mount Perales. A broad valley, with Taltal sits at its mouth, cuts through the coastal hills and forms a distribution barrier to several copiapoa species. the roofs in the near valley are hothouses erected to take advantage of a fog collection scheme (now defunct) based on two water collectors near the top of Mount Perales.

Taltal to Chañaral

South of the Taltal valley, the terrain changes significantly from that of the north. The coastal hills, which in the north form a continuous barrier some 600-1200 m high, become much lower and are broken by six major valleys, each of which allow fog to penetrate inland. As a result, copiapoa grow much further eastwards than in the north. South of the Cachina valley, which is about half way between Taltal and Chañaral, the coastal hills again form increasingly high cliffs which suddenly drop off near Pan de Azucar. South of this, the hills become lower and are frequently broken by valleys. Because of the many steep valleys and the lack of a continuous coastal plain, there is no coastal road between Taltal and Pan de Azucar.



In the south, Chañaral lies in a broad flat, sand filled valley which appears to act as a barrier to copiapoa species. *C. cinerascens* extends south into the next sector, *C. hypogaea* and *C. marginata* extend into this sector from their main range further south. All three species show marked differences in their form on either side of the Chañaral valley.

The climate of the Taltal to Chañaral sector does not vary much from north to south. Generally, it is significantly drier in this sector than north of Taltal, mainly because the coastal hills are not high enough to intercept heavy fogs and mists. The exception is the fog oasis on the highest hills (just above 700 m) north of Pan de Azucar which has very well developed vegetation along the cliff edges. Because of the abundance of valleys and the lower hills, the true desert does not start until 10 km from the coast and in some cases, where the valleys are open and allow fog unhindered flow inland, plants can grow as far as 20 km inland.

Associated organisms

As in the sector further north, *Deuterocohnia chrysantha*, *Eulychnia brevifolia* (form 'Saint-pieana'), *Oxalis gigantea* and *Euphorbia lactiflua* dominate the landscape, however they are not as abundant because the hills are often not high enough to enter the fog zone. As a result, these fog plants do not form the almost continuous shrub covering seen on the more favorable sites further north.

Cactus of the genus *Eriosyce* (sensu Kattermann) are more common in this sector. Species in the section *Thelocephala* are the most common, often on the extensive, gently sloping granitic hills. In some places, they can form populations numbering in their thousands however these are seldom seen as they spend most of their lives partly buried under gravel. In some cases, populations extend 30 km inland, at least 8 km further towards the true desert than the most hardy copiapoa or eulychnia. *Eriosyce rodentiophila* is common and grows for the most part near the inland edge of copiapoa distribution, however at a few locations it grows near the sea where it is very dry (such as near Cifuncho). *Eriosyce* (*Neoporteria*) ???, and ??? can also be found but not in any great abundance.

Man's influence in this sector is minor with mining being the only activity in the copiapoa habitat. At present there are no active mines in the sector. A coastal road from Pan de Azucar is planned and this will no doubt increase development.

▼ Looking south into the Guanillos valley (yellow arrow) and the Esmeralda valley (green arrow). The Guanillos valley contains the greatest diversity of copiapoa species. The hillside in the foreground (800 m) supports only *C. grandiflora*. As one descends, *C. longistaminea*, *C. columna-alba*, *C. laui* and lastly *C. sp* 'Guanillos' appear.





- ▲ Guanaco are quite destructive in this sector, attacking both the stems (*C. longistaminea*, above) and the tuberous root (*C. taltalensis*, right). Note how they have scratched away the rocky covering and dug into the ground. The regrowth has recently died.
- ▼ Leo van der Hoven on the cliff edge 3 km south of Esmeralda. The area from here to the south is a wide coastal plain with steep hills. *C. grandiflora* and *C. longistaminea* grow on the plains and hill-sides. *C. hypogaea* grow on the hilltops.



Copiapoa distribution

This sector has the greatest number of species, even though it is the smallest. Eleven species are represented and in one location, four grow together. *C. cinerascens* grows only in the south at low elevations near the shore. A subspecies grows south of Chañaral. *C. cinerea* ssp. *columna-alba* grows mostly in large dense populations throughout the sector, usually away from the shore and at higher elevations. *C. grandiflora*, a soft bodied species, grows from Pan de Azucar to the Guanillos valley. *C. hypogaea* (covered in the next sector) extends from Chañaral to almost Esmeralda. *C. laui* is known from four distinct small populations in the central area, nowhere does it form extensive populations. *C. longistaminea* grows from just south of Esmeralda to Cifuncho, mostly at low elevations. *C. mollicula* has the most restricted distribution, being found near the tops of a few hills just north of Chañaral. *C. marginata* has its northernmost distribution between Chañaral and Pan de Azucar as the form 'Bridgesii'. Its distribution is mostly inland from the immediate coastal hills. *C. rupestris* occurs as two subspecies from Cifuncho to Taltal. Along the coast ssp. *rupestris* grows on the coastal rocks and hills but only to about 3 km inland. Further towards the desert, ssp. *desertorum* is found in a few discontinuous populations. It also has a population near the coast which forms a transition to ssp. *rupestris*. *C. serpentisulcata* has a small but dense population which grows only along the coastal plain and the cliff tops just north of Chañaral. *C. taltalensis* (*C. hornilloensis*) grows over a wide area between the Cachina and Tigrillo valleys, usually to the inland of the other copiapoa species. *C. sp.* (Guanillos) has a very restricted population in the Guanillos valley.



▲ Part of a large clump of *C. cinerascens*.

C. cinerascens (northern form)

With its white stems forming low symmetrical mounds, the northern form of *C. cinerascens* is one of the easiest species of copiapoas to visit in the field. The best colonies grow near the coastal road north of Chañaral, forming extensive, dense populations on the coastal plains just south of Pan de Azucar. Plants vary within their population, mainly in spine length and number but on average, the plants are rather uniform when compared to other species. The stems on single headed plants are usually wider than they are high, offsetting readily. The form of the species growing north of Chañaral is essentially coastal, generally only growing under 200 m in elevation. In spite of several attempts to locate plants at higher elevations and further inland, no further populations from what were known in 1996, have been found north of Chañaral.

Mature plants north of Chañaral have shown a remarkable recovery from those photographed in 1996, when it was difficult to find plants that could be considered turgid. Many plants which we thought would never recover have done so and are now plump and flowering regularly. This species do not appear to be subject to borers or diseases. Plants seldom show a discolored or damaged epidermis.

C. cinerascens frequently grows loosely associated with *C. serpen-*

▼ *C. cinerascens* (left), growing with *C. serpentisulcata* along the coastal road north from Chañaral. Both plants are fully pumped up with water.



tisulcata but they rarely grow closely together. *C. cinerascens* prefer the more gravelly flat areas while *C. serpentisulcata* grows on the steeper and rockier outcrops. Occasional hybrids with *C. serpentisulcata* occur where the species grow together. Sometimes a few *C. cinerascens* can be found in the dry river valleys where there are large numbers of *C. columna-alba*, these have come from further up the valleys where *C. cinerascens* grows as pure populations.

C. cinerascens appears to freely hybridize with *C. grandiflora* on its northern boundary. The northernmost population of *C. cinerascens* are not far removed in their characteristics from some *C. grandiflora*, leaning support to the suggestion that the two taxa should be considered one species, however, typical plants of each species are quite distinct.

On rare occasions, *C. cinerascens* grows with *C. cinerea* ssp. *columna-alba* and with isolated *C. marginata*. No hybrids have ever been found with these species.

C. cinerascens also grows in larger numbers south of Chañaral (see page ??). Plants from the inland valleys are quite different from the typical northern *C. cinerascens* and may deserve subspecies status. This book refers to these as *C. cinerascens* (southern form).



▲ A single stemmed *C. cinerascens*, growing on the rocky coastal plain north of Chañaral. Compare this plant with the southern subspecies on page ???.

▼ A large clump of *C. cinerascens*.





At high elevations (above 600 m) most *C. cinerea* ssp. *columna-alba* populations have long and thick spines. This corresponds to Ritter's *C. melanohystrix*.

C. cinerea ssp. *columna-alba* near Pan de Azucar. While most plants are single stemmed, there are some with up to fifteen individual stems.

C. cinerea ssp. *columna-alba*

C. cinerea ssp. *columna-alba* differs from the species in having more ribs, shorter spines and a tendency to remain single stemmed. Mature plants almost always show a pronounced lean towards the north.

The southernmost population of *C. cinerea* ssp. *columna-alba* grow on the tops of the hills just inland and north of Chañaral. The northernmost population grow to within 4 km of Taltal. Here, it grows near the tops of the low coastal hills. These coastal plants, some of which grow below 100 m in elevation, have short white spines as opposed to the darker or even black spined plants growing at higher up in the hills. Plants can grow to at least 900 m elevation.

Inspections of over thirty *C. cinerea* ssp. *columna-alba* populations failed to reveal other copiapoas (except *C. rupestris*) growing among the main population. Occasionally, *C. longistaminea*, *C. cinerascens* or *C. gandiflora* grow near the edge of a *C. cinerea* ssp. *columna-alba* population but the main body of plants are always monospecific. Why this is so is an intriguing question. Perhaps it relates to the genetic dominance of *C. columna-alba* genes where hybrids (which may be common) take on the phenotype (outward form) of *C. cinerea* ssp.



columna-alba, eventually ‘swallowing’ up any traits inherited from the other parent. There is some evidence (via cultivated plants) that this is so, with seedlings of *C. longistaminea* plants (from ‘Secret Valley’) showing *C. cinerea* ssp. *columna-alba* characteristics. Further seedling studies may clear up this matter. This will require the collecting and growing of seeds from *C. gandiflora* and *C. longistaminea* which grow near *C. cinerea* ssp. *columna-alba* plants to see if any resulting seedlings show *C. cinerea* ssp. *columna-alba* characteristics⁽¹⁾.



- ▲ A ‘young’ plant of *C. cinerea* ssp. *columna-alba*⁽²⁾. Note the new spines. Because of its white epidermis, this seedling may be several decades old. Extensive searches in favorable habitats failed to reveal any young plants (two to five years old).
- ◀ A very dense *C. cinerea* ssp. *columna-alba* population growing on the hills north of Chañaral (at 500 m). The yellowish tinge is caused by lichens which grow on the windward (west) side of the plants.
- ▶ *C. cinerea* ssp. *columna alba* about 8 km northwest of Cifuncho. Some plants become multi-headed and resemble *C. cinerea* in general growth form.
- ▼ Healthy ‘young’ plants of *C. cinerea* ssp. *columna-alba*. Note how far the wax extends down the sides of the stems.





▲ A healthy *C. grandiflora* during the wet winter of 2002.

- ▼ *C. grandiflora* with beetle grubs. All of the soft bodied copiapo species are susceptible to this grub which can eventually kill whole clumps. These grubs are nearly ready to pupate after having hollowed out a stem each.

C. grandiflora

C. grandiflora has a soft body and a large taproot. The flowers are the largest within the genus. Plants typically form small clumps up to 20 stems however in its core area they can be much larger. The relatively flat topped stems, which have a thin waxy coating, have a gray coloration. The apex is not very woolly, even on plants which are producing new spines. With its soft body, stressed or old plants are often infected with boring grubs which eat out the inner tissue (see photo below). *C. grandiflora* grows from near Pan de Azucar to the Tigrillo valley, usually near the coast.

During 2003 the core area for this species was discovered. It lies between 450 m and 600 m some 4 km south of Esmeralda. Here, *C. grandiflora* forms pure stands on the northeast facing slopes just inland from the coastal cliffs. The higher elevations receive direct fog, plants here are heavily encrusted with lichen. The best looking plants grow at around 500 m in a location where they are in a 'fog shadow' created by hills which block the flow of fog from directly passing by the plants. Some plants here reach over 1 m in diameter and have over 100 stems.



C. grandiflora hybridizes with *C. longistaminea* (see page ??) as well as with *C. cinerascens*. The later species does not grow further north than Pan de Azucar, however the hybrids grow around 9 km further north. Here, they grow on the upper coastal terraces of many valleys. Many plants are suffering and shrunken, making appraisal of their characteristics more difficult. A visit to this site (26°03'S 70°38'W) during a wet year when stems are plump and showing more body than spines should make assessment easier. *C. grandiflora* shows considerable variability in epidermis colour, spine length, and abundance and size of stems. The frequent hybrids with *C. longistaminea* (particularly evident along the coastal areas south of Esmeralda) make it difficult to decide if spiny plants are hybrids or just various forms of *C. grandiflora*. Hybrids have a harder body and are less squish than *C. grandiflora* but this depends on the degree of stress⁽⁴⁾.

C. grandiflora grows with *C. longistaminea*, *C. hypogaea*, *C. laui*, *C. columna-alba* (only marginally) and rarely with a few *C. marginata* 'Bridgesii'



▲ This *C. grandiflora*, which was uprooted by a flood three years prior, shows a definite swollen root. The plant, now without active roots, appears to still be alive.

▼ Two extreme forms of *C. grandiflora*. Neither of these two forms represent typical plants of this species. the form on the right suggests *C. longistaminea* 'blood' however none were present near this location.





▲ A large headed form of *C. laui*.

▼ As a general rule, the fewer the heads per clump, the larger the individual stems.

C. laui

By far the smallest copiapoia species, *C. laui* is characterized by its tiny stems which form dense flat mats. While individual stems are relatively soft, whole plants can withstand being trodden on without damage. Plants have only been found growing in decomposing granite where the stems are often partially covered with gravel. They prefer to grow on relatively flat ground, usually on hillsides which face north.

In recent years, new populations of *C. laui* were found to the north of the Guanillos site, which is the type location. One outlying population grows about 11 km to the north north. Here, plants are more vigorous and can have larger heads. They also show more variability, especially in stem size and the degree of offsetting. At present four populations are known. It is expected that new populations of *C. laui* will be found between the Guanillos Valley and Cifuncho.

The Pan de Azucar population is quite small, with plants much



more widely scattered than the populations further north. While most plants had larger stems than the Guanillos population, this is believed to mainly be a function based on the degree of offsetting. Plants of *C. laui* which offset profusely having small heads, those that offset less prolifically have larger stems (see photo, below).

The health of *C. laui* appears to be similar to the situation during 1996, when we first visited the plants. Dead plants are not apparent but this may be because these rot quickly and disappear. Animal predation on *C. laui* is uncommon, but becoming more frequent, suggesting that this species, which grows in locations where guanaco could easily dig and eat them, are too bitter to be palatable and are only being chewed during the most severe drought times.

C. laui grows with *C. columna-alba* (at the edge of the population), but among *C. grandiflora*, *C. longistaminea* and *C. sp.* 'Guanillos'.



▲ *C. laui* growing on a coastal hilltop north of the Tigrillo Valley. Here, the stems are relatively large but the number of stems is much lower than in the Guanillos valley. (photo: Leo van der Hoven)



◀ A small plant of *C. laui* growing with two *C. sp.* 'Esmeraldana' in the Guanillos Valley. While both species grow in the same area they seldom grow close together. The single round object on the right of the *C. laui* is goat droppings.

▼ *C. laui* in the collection of Ingrid Schaub and Ricardo Keim. The flowers will be open in the afternoon, virtually covering up the whole clump. This plant has been grown hard and closely resembles healthy habitat plants. (Photo: Ricardo Keim)





Two *C. longistaminea* from Tigrillo. Plants growing near sea level generally form much smaller clumps than inland populations. Plants at lower elevations also have spines which are lighter in color.

Variation within *C. longistaminea* growing near Caleta Madeira. Most plants range in appearance between these two extremes.

C. longistaminea

C. longistaminea is characterized by hard, wax covered stems which form tight clumps with up to 100 stems. The wax covering is thick and gives plants, especially those growing in very dry and stressed situations, a whitish-blue appearance. The spines are usually brownish but are often stained blackish by algae.

During 2003, the core area for this species was discovered. It lies at 300-400 m in elevation, about 2 km south of Esmeralda. Here, it forms dense single species populations. At higher and at lower elevations, it mixes with *C. gandiflora*. At the extreme eastern edge of its population it comes in contact with *C. cinerea* ssp. *columna-alba*. The core area is impressive, with many clumps well over 1 m in diameter. Many plants show obvious variability in size, length of stems, growth form, spine characteristics and stem color.

As first noted in 1996, *C. longistaminea* stems are still being eaten from the apex by guanaco (see page ???). Damaged stems are cored out to a depth of about 125 mm, usually in an hemispherical shape. These stems usually rot with the next rain event however a few survive, close up on themselves and produce numerous offsets. It is now common to find many *C. longistaminea* with dead stems, all of which were seemingly initiated from guanaco damage.

C. longistaminea hybridizes with *C. gandiflora*. The area with the greatest hybridization is on the coastal terrace near the southern extent of both species range (see map, page ??). Here, a clear transition exists with the population consisting of many thousands of plants showing typical examples of both *C. longistaminea* and *C. gandiflora* as well as all imaginable hybrids. In several locations, all *C.*



grandiflora and *C. longistaminea* have died with only the hybrids still surviving. Near the extreme north of the range, where both species co-exist, there is a smaller but obvious hybrid population. One apparent *C. longistaminea* x *columna-alba* hybrid (see page ???) was found near the core area of *C. longistaminea*. The plant resembles *C. cinerea* ssp. *columna-alba* far more than *C. longistaminea*.

The northernmost *C. longistaminea* from Cifuncho differ in several respects from the southern populations. In 'Copiapo 1996' we suggested that this population may be a different species. With more thought and further exploration along the coast to the south, it is now clear that the plants here are the most northern population of a widespread and variable *C. longistaminea*. I have walked for several hours along the coast south of Cifuncho and found many thousands of plants which gradually become less stressed. They progressively exhibit characteristics more typical of *C. longistaminea* growing south of Quebrada Leoncitos (photo right). We have grown seedlings from this population and compared them with more typical *C. longistaminea* from near Esmeralda (which are actually near the southernmost extent of the population). While seedlings show minor epidermal and spine coloration differences, this is not enough differentiation to support any separate taxonomic ranking.

C. longistaminea grows with *C. grandiflora*, *C. laui*, *C. sp.* 'Guanillos' and *C. cinerea* ssp. *columna-alba*.



▲ A. *C. longistaminea* from Quebrada Leoncitos (about 12 km south of Cifuncho). Plants grow in interior valleys protected from salt spray. Compare this with the Tigrillo plants shown on page ???.

▼ The northernmost population of *C. longistaminea* was originally considered as deserving its own taxonomic rank. The coastline near Cifuncho is drier than further south so coastal plants are subjected to regular salt spray. This bleaches the spines and keeps them from graying. The lack of fog creates sun stress which intensifies the bluish-white epidermal wax.





▲ An old *C. marginata* 'Bridgesii' growing near the base of a large *Eulychnia saint-pieana*.

▼ An attractive clump of *C. marginata* 'Bridgesii' which shows a less than the usual rib count.

C. marginata 'Bridgesii'

This plant represents the northernmost form of *C. marginata*. Typical plants have an abundance of white apical wool. The rib count varies from 8-10, which is fewer than typical *C. marginata*. Mature plants form clumps with taller, fewer and thinner stems. While plants look significantly different from the *C. marginata* from Cerro Copiapó (90 km to the south), they do not vary much when compared to *C. marginata* growing just south of Chañaral.

Plants are suffering today from die-back and stress more than in 1996. Single headed plants, especially those growing in partial shade among cliffs or dry river boulders, appear healthy whereas mature plants growing near the hilltops are mostly dead or dying. Soon, only single headed immature specimens will represent this species. It is interesting that the core population, which occurs just east of coastal hilltops, is now not surviving well whereas plants growing at the margins of the population at lower elevations under the fog zone are surviving better. This species seems to have had a shift in habitat preference, from the misty fog zone to a drier environment. *C. marginata* 'Bridgesii' grows with *C. mollicula*, *C. hypogaea* and marginally with *C. cinerea* ssp. *columna-alba*.





▲ A very healthy *C. marginata* 'Bridgesii' growing at 300 m elevation.



▼ The most distinguishing characteristic of mature *C. marginata* 'Bridgesii' is the very woolly apex. Note how the wool extends down the ribs. In habitat, the wool quickly stains grey as the result of algal growth.



◀ A large *C. marginata* 'Bridgesii' growing out from a dormant bush. Note how vegetated the area is in the background. Very few young plants were found in this population.



- ▲ This protected *C. mollicula* shows a few new black spines, indicating that it produced some new growth last year.
- ▲ Most healthy *C. mollicula* are surviving among large rocks where they receive additional run-off and are protected from guanaco and donkey predation. This plant shows no wool, indicating that it has not produced any new growth for many years.
- ▼ A plant with shorter than normal spines. *C. mollicula* in cultivation develops extensive wool, plants in habitat seldom do, and if so, it is stained gray by algae as on this specimen.



C. mollicula

With one of the most restricted of habitats, *C. mollicula* is also the rarest of copiapoa species. Plants are characterized by their small, hard bodies which produce an abundance of wool, however, this is not as evident in habitat specimens as it is in cultivated plants. The whole population is not coping well with the dry conditions and the plants which are still surviving may not be a true reflection of what the species is capable of growing into⁽⁵⁾. Many plants have no wool in their apex, showing that they have not grown for many years.

Ritter's habitat description is quite precise for this species. He described it as growing on the hills above the Chañaral airport. We visited the hill closest to the airport and found scattered plants growing on the top and northern slopes (500 m). Scattered plants extend down the hill on the southern slope. The habitat is small, perhaps only 3 km². Old, mature plants were very rare, with only the younger and smaller plants surviving. Most of the plants were found on north facing slopes and signs of dead plants were far more common than living specimens. The higher hills further inland support only *C.*



cinerea ssp. *columna-alba* while the coastal hills further north are dominated by *C. serpentisulcata*.

The *C. mollicula* of cultivation resembles the plant in habitat, however cultivated plants are usually woolly, lush and much taller than habitat plants.

C. mollicula is endangered from natural habitat destruction caused by drought. Most of the associated plants, including the very hardy *Euphorbia lactiflua*, have died. The numbers of *C. mollicula* in habitat may number only in the low thousands, making this species among the rarest of copiapos.

C. mollicula grows together with a few *C. hypogaea* and *C. marginata* 'Bridgesii'. No hybrids have ever been found.

It appears that many of the plants in cultivation under this name are hybrids, most likely with *C. grandiflora* or *C. humilis*. Because of the rarity of plants in habitat and the lack of seeds, correctly named plants in cultivation will always be rare.



Most of the *C. mollicula* are showing no signs of recent growth. The plant shown here has extensive lichen growth on the areoles and spine bases which only develops on old plants. This plant has stout spines, typical for most of the plants still present in habitat.

- ▼ The habitat of *C. mollicula* on the hilltops north of Chañaral (visible in the distance). The elevation is about 500 m. Plants prefer northerly facing slopes.





▲ A single stem of *C. rupestris*, photographed at the core population north of Cifuncho. Unlike the coastal plants which have clean spines, plants here grow near the lower fog level and have spines which are stained by algae and lichen. Compare this photograph of an atypical *C. rupestris* with pages ??? and ???

↙ View from the core area of *C. rupestris* towards the south. Cifuncho lies at the base of the hill in the far distance (yellow arrow). Another population of *C. rupestris* (blue arrow) grows on the hills to the left. The southernmost population (red arrow) grows south of Cifuncho.

▼ A large specimen of *C. rupestris* from the core population north of Cifuncho. Some plants had over sixty stems. Plants which are growing on foggy ridges have gray spines all the way down the stems and look substantially similar to some forms of *C. marginata*.



C. rupestris ssp. *rupestris*

C. rupestris is one of the most diverse copiapoa species and difficult to delineate other than to say that it has hard bodies, an enlarged taproot and grows between Cifuncho and the San Ramon Valley.

The coastal population (which includes Ritter's *C. rubraflora*), has its core area in the mountains just north of Cifuncho at elevations of 200-400 m. Here, plants develop into large, one, meter clumps consisting of up to seventy stems and resembling some forms of *C. marginata* (see page ???). These plants are quite different from the often photographed and visited plants along the coast just south of Taltal which consist of mostly juvenile stems shooting up from the enlarged taproot. Almost all the coastal plants have shed their mature stems during recent drought episodes and have re-sprouted during wetter years, resulting in stocky stems quite unlike the mature plants growing higher up in the core area. Because stems of coastal plants are relatively young (several decades at a minimum), they are more brightly spined and clean when compared to mature stems from core area plants. This can lead the novice copiapoa traveler to assume that there may be two separate taxa in question⁽⁶⁾.

The population of *C. rupestris* growing north of Taltal was apparently not known by Ritter and is seldom in collections. In 'Copiapoa 1996' we presented several photographs of plants taken from near the floor of the Quebrada San Ramon where a number of smaller plants



grow. It was not known how these plants connected or had reached the closest coastal *C. rupestris* population (which is some 9 km distant to the southwest). Further investigations revealed that the inland population is far larger than first thought, extending from the mid-reaches of the San Ramon Valley (at 250-550 m) up the north facing slopes and over the top of Cerro Breas (1000 m) and down the southern and northern flanks along some of the rocky slopes. The core area appears to be at around 600-900 m. Plants grow at the edge of the desert in places which are too dry for *C. cinerea* or *C. krainziana*. On the lower, mostly north facing slopes, *C. rupestris* grows with *C. krainziana*, but only on the edges of that population.

The relationship between the two distinct populations of *C. rupestris* ssp. *rupestris* is unclear. The southern population is coastal, seldom growing more than 5 km from the shore. The northern form is a mountain species, growing up to 1000 m and extending inland further than *C. cinerea* or *C. krainziana*. The most inland plants (form 'Aphanes', see page ???), grow at least 15 km from the ocean.

In its core population, *C. rupestris* grows alone. Along its margins, it grows with *C. cinerea* and *C. cinerea* ssp. *columna-alba*. Plants of *C. rupestris* growing in the San Ramon Valley among *C. cinerea* and *C. krainziana* should be considered as invaders, having been washed down from their true population higher up on the surrounding hillsides⁽³⁾.

Ritter gave species status to the red flowering population of *C. rupestris* (*C. rubraflora*), plants growing south of Taltal, claiming that they were distinctly different enough from the more southerly and inland forms to be of species status⁽⁴⁾.



▲ A *C. rupestris* from near the coast. It is rare to find plants showing this much sign of flowering.

▀ A healthy *C. rupestris* with relatively thin spines. The healthier the population, the greater the variation within it.

▼ A seedling growing almost buried among decomposing granite. Seedlings grow partly buried for many years before gradually emerging at the size shown. Young plants growing as reshoots from the swollen taproot grow much quicker and are not as densely or thickly spined.





▲ Typical *C. rupestris* ssp. *desertorum* growing in the core area at around 450 m elevation.

▼ A healthy *C. rupestris* ssp. *desertorum* growing during the wet year of 2003. Note the abundant flowering and the large size of the dry fruits. The green body is usually not as evident during dry years because the body shrinks and is less visible through the dense spine cover.

C. rupestris ssp. *desertorum*

C. rupestris ssp. *desertorum* is characterized by very heavily spined stems which, on old plants, form dense mounds. Much of the stem features are obscured by the heavy spination. Young plants have a thick taproot however it is very difficult to find any single stemmed plants so this feature is best seen on cultivated seedlings. The flowers and fruits are usually reddish, a characteristic shared by ssp. *rupestris*.

I originally considered *C. desertorum* to be distinct from *C. rupestris*, however the large transitional population south of Cifuncho shows that the plants are closely related and subspecies status may not be warranted. It is still placed in the book with this ranking because of its well known status and its former rank as a species.

The core area for this species lies inland from Cifuncho at 400-550 m. Here, plants can be composed of hundreds of individual stems which form dense clumps in excess of 1 m in diameter. The core area is about 4 km² in area. Plants formerly grew in old alluvium deposits in the valley which runs towards Cifuncho but almost all of these plants have now died. The near coastal (near Cifuncho) and the southernmost populations are the most stressed. Older plants show a much more open growth habit similar to *C. rupestris* ssp. *rupestris*. Most of the larger plants have died, however many single headed specimens survive ⁽⁹⁾.

Splitters have argued that *C. desertorum* looks and grows signifi-



cantly different from *C. rupestris* ssp. *rupestris* and this should be enough to retain it as a species. This belief is based on the differences seen when comparing typical *C. rupestris* ssp. *desertorum* to the coastal population of *C. rupestris* ssp. *rupestris* which consists of few stemmed plants with low-elevation characteristics (yellow spines instead of gray or black). When these plants are compared to typical *C. rupestris* ssp. *desertorum* clumps (see photo on left), plants appear quite different. But let us look at other, selected plants from both taxa. Compare the photo below to the *C. rupestris* ssp. *rupestris* shown on page ?? . Both of these come from the core area for both taxa, showing how important it is to compare plants with similar ages and conditions when assessing taxonomic affinities.

C. rupestris ssp. *desertorum* does not grow intermingled with any other copiapoa however it does come close to *C. cinerea* ssp. *columna-alba* populations along its margins. No hybrids between *C. rupestris* ssp. *desertorum* and *C. cinerea* ssp. *columna-alba* have been noted.



▲ A number of copiapoa can have reddish flowers. Here, a *C. rupestris* ssp. *desertorum* exhibits 'rubraflora' characteristics. It is unknown if the red pigments responsible for reddish flowers are produced annually or only in response to seasonal conditions. Reddish flowers have also frequently been noted in *C. solaris* and *C. coquimbana*.

☞ Typical *C. rupestris* ssp. *desertorum* habitat, near the type locality about 20? km inland from Cifuncho. *C. rupestris* ssp. *desertorum* grow near the desert's edge where few other plants can survive.

▼ Plants in the transitional population south of Cifuncho show intermediate traits between *C. rupestris* and its subspecies *desertorum*.





▲ A two headed *C. rupestris* 'Aphanes'. All such plants grow from large roots where the original and more typical *C. rupestris* stems have been dislodged, most likely several times. With each removal, the new offsets take on a more juvenile form.

✦ *C. rupestris* 'Aphanes', side view. The definition of the areoles depends on how stressed the plants are. This plant was unusual as it grew out from a rock crevice.

▼ *C. rupestris* 'Aphanes' habitat, north of Las Breas. Most plants grow on south facing slopes at elevations between 700 and 800 m.



C. rupestris 'Aphanes'

First described as a species in 2004, this plant generated some suspicion among frequent cactus travellers to Chile as it was the first new copiapoa species described for many years⁽⁷⁾. The location given was Taltal, a well known area not expected to reveal any new discoveries. The authors (Mächlin and Walter, 2004) gave little away as far as the exact location of the three small populations other than that it grows with *C. cinerea* and that it grows inland. Paul Hoxey provided me with a possibility for a location as he found some plants which were unknown to him at the time of his first visit to the area in 2001.

Visiting his recommended location, we (the author, Ricardo Keim and Ingrid Schaub) found a population of copiapoa which was very similar to the plants illustrated in the description. These grow on the south facing slopes of the hills north of Las Breas (see map, page ???). To us, the plants in question are merely a stressed form of the widespread and diverse *C. rupestris* ssp. *rupestris*, which grows on the nearby hills from an elevation of over 1000 m. An interesting feature of the northeastern form of this species is that lower elevation forms on south facing slopes have progressively smaller bodies and thinner spines than those higher up the mountain. We believe that Mächlin and Walter have mistaken this inland and lower elevated form of *C. rupestris* for a new species (*C. aphanes*) and unfortunately published it in a well recognized and respected journal. This 'species' appears to



be no more valid than Ritter's *C. columna alba* var *nuda* which turns out to be just another example of a highly stressed form which was unfortunately given taxonomic status. While we may be mistaken in our interpretation of *C. aphanes*, it now lies in the hands of the describing authors to verify that it indeed is not just a form of the common and variable *C. rupestris*.



▲ This habitat plant shows the pink petal stripes which are said to be a feature of *C. 'Aphanes'*. This feature is common in many populations of *C. rupestris*.



▲ An unusually large clump of *C. rupestris* 'Aphanes'. Most plants were single headed.

▼ Plants like this were originally considered to be an *Eriosyce* however intermediates show that this is just a very juvenile form of *C. rupestris* 'Aphanes'. If the root does not die and the stem is not dislodged, such shoots will eventually form 'Aphanes' type spines.



▲ Near the top of the mountain, plants can be recognized as being fairly typical for *C. rupestris*. Plants of the mountain form do not develop the yellowish spines of the coastal form as these plants grow within the fog zone at 700 m.

▼ Near the top of the mountain above *C. 'Aphanes'* there are a few remnant mature *C. rupestris*. Below this plant there is a gradual transition with many intermediates.





▲ *C. serpentisulcata* (right) with *C. cinerascens*. The two species grow in the same area but prefer differing habitats. *C. serpentisulcata* prefers more broken ground while *C. cinerascens* prefers the rubble slopes. Plants in the mid-distance are all *C. cinerascens*.

▼ Mountain habitat of *C. serpentisulcata*. Plants grow near the edge of the cliff face and only extend 300 m inland. Note how the plants are discolored when compared to those growing below the fog.

C. serpentisulcata

C. serpentisulcata is a clumping, non-waxed covered species with dense, relatively short spines which are brownish in colour when not stained by algae. Clumps can have over 50 stems but these seldom elongate with age nor do they regularly stem sacrifice with age (%) like *C. cinerascens* with which it grows⁽⁵⁾. *C. serpentisulcata* appears not to be closely related to any other species and is one of the most distinct copiapoas. The variation within the species seems less than for other species but this may just be because the dense spine covering distracts from noticing differences in stem features.

Plants along the coastal road, which are the only *C. serpentisulcata* seen by most copiapoas tourists, are surviving well and are in better condition than in 1996. These coastal plants, many of which have light brown or golden spines (the *C. castinea* of Ritter) look significantly more attractive than the core population plants growing at 300-400 m on the coastal hills. This mountain population is the



healthiest of any *Copiapoa* species, having regeneration with small plants and even seedlings evident in the most favorable sites. The population is very dense in places, with up to one plant every two square meters. Plants from the hill population have stained spines, giving the plants a gray appearance. This contrasts with the bright spined plants often seen in photographs take along the coast and below the fog zone⁽⁶⁾.

No new populations of *C. serpentisulcata* have been found in our explorations. As far as we know, this species is restricted to a 12 k long by 1 k stretch along the coast just north of Chañaral. Hill population plants seldom extend inland for more than 300 m from the immediate cliff edge.

Occasional hybrids with *C. cinerascens* can be found near the coastal road where the two species share the same habitat. No hybrids with *C. marginata* or *C. hypogaea*, with which it also grows, have ever been found.



▲ Mountain form of *C. serpentisulcata*.

▼ A typical coastal form of *C. serpentisulcata*, showing new spine and wool growth. (photo: Tom Knappic)





▲ A typical habitat for *C. taltalensis* on Cerro Esmeralda (1080 m). The habitat, especially in the eastern part of the range, is very barren. Inset: A less spiny form of *C. taltalensis*. This plant comes from the lower Tigrillo Valley (200 m). Some low elevation plants look like they could be hybrids with *C. grandiflora*.

▼ *C. taltalensis* plants tend to grow with their stems partially contracted into the ground. This gives them some support and offers protection from guanaco and donkeys which try to get at the swollen root by breaking off the stems at a narrow neck. The ruler divisions are 10 mm.



C. taltalensis (Ritter's *C. hornilloensis*)

C. taltalensis is a very variable species with a wide distribution range. If looking only at its extreme forms, many observers would conclude that there are three species: the mature form, the spiny high elevation form and the short spined, bristly lowland form. Many intermediates exist.

Ritter seems to have been unaware of the Werdermann (1929) description for this plant which he later invalidly named *C. hornilloensis*. All in all, it would have been a far better name as it accurately describes the location where this species grow, far south of Taltal.

C. taltalensis grow in dry areas near the desert's edge in the neighborhood of Cerro Hornillo which lies to the northeast of Esmeralda. Apparently Ritter and Werdermann only found juvenile plants as he failed to record the mature form of this plant, which grows offsets and can become twice as large as he indicates (50-100 mm in diameter). The mature plant on the left was photographed at 1000 m on the slopes of Cerro Esmeralda. Mature plants are very rare, apparently they have been all but destroyed by guanaco and donkey predation. The typical plant found corresponds well to Ritter's description, however plants from lower elevations have far fewer and weaker spination (this is typical for all copiapoas). Plants typically grow level with the ground, with a long and thickened root (without a narrow neck) that is contractile and can pull the spiny plant into the loose rubble when conditions are dry⁽⁷⁾. This contractile feature is not common with other hard bodied copiapoas which all seem to have a narrow and fragile neck.

The distribution of *C. taltalensis* extends 13 km from east to west and at least 18 km from north to south. We found plants at elevations of 1050 m down to 200 m. The lower elevation plants grow in the Tigrillo Valley. It is mostly found in the drier, more barren habitats, often growing on bare hillsides or in the old alluvial deposits of the Tigrillo valley and its tributaries.

C. taltalensis flowers periodically with a few fruits being produced through the winter months. One small plant (25 mm diameter) was found partially buried in loose rubble, suggesting that seedlings remain partially buried for many years.

C. taltalensis is suffering more from drought and guanacos than those species growing in the wetter coastal areas. Even in its core areas on the slopes of Cerro Hornillo (850 m), there are many more dead than living plants. *C. taltalensis* is widely scattered in all the populations visited. Plants appear to grow in small 'family' groups. Today, large areas of suitable habitat are without plants. Guanaco and

donkeys dig around on the plants and once the heads are dislodged, the root tops are exposed and can be eaten. The number and frequency of guanaco diggings in *C. taltalensis* habitats show that this species was much more common than it is today.

Ritter noted that *C. taltalensis* seeds are identical to those of *C. rupestris* ssp. *desertorum*, which grows further north (14 km) and is not contiguous with the range of *C. taltalensis*. This similarity appears to be the basis on which Charles (1998) and the IOS have decided that *C. taltalensis* should be lumped together with *C. rupestris*, all becoming varieties of *C. taltalensis*. I believe this was a wrong decision based on a lack of field observation. Further investigations, especially of seedlings, may shed more light on the links between *C. taltalensis* and *C. rupestris*.

C. taltalensis does not grow with other copiapoa species, except for a narrow band along the inland margins of some *C. cinerea* ssp.



▲ Younger stems, which grow as new shoots from the taproot of plants which have had the original stems dislodged by guanacos and donkeys, appear quite different from mature stems. This dimorphism is common among copiapoa species.

◀ A mature *C. taltalensis*(?), growing out from a cliff rock crevice where the root is protected from predation. It is very rare to find plants which are taller than they are wide. Plants like this were originally assumed to belong to a new species. If this is indeed a mature *C. taltalensis*, then all the other plants are showing only immature features.

▼ *C. taltalensis* can have a very long taproot. In this case, the loose alluvial soil allowed the root to grow to its full potential. Note how the root neck is only slightly narrowed ⁽⁸⁾.





Two *C. sp.* 'Guanillos'. The lower plant is stressed.

C. sp. 'Guanillos' showing the variation within the species. The plant in the upper right is a *C. laui*.

C. sp. 'Guanillos'

= *C. esmeraldana* of Schulz & Kapitany (1996)

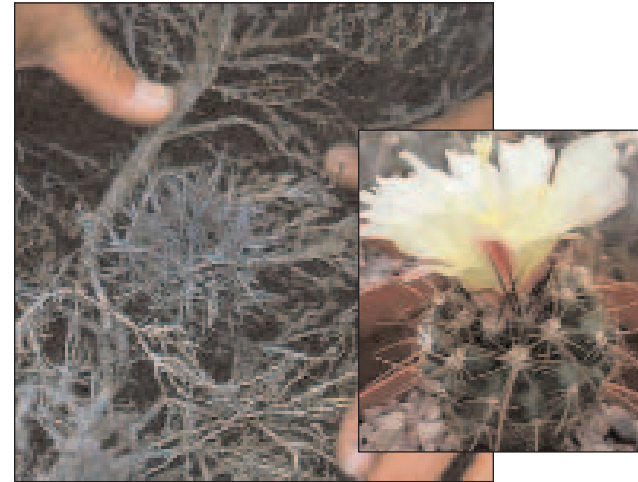
C. sp. 'Guanillos' is a small growing, soft bodied species with a very peculiar association and restricted distribution. While resembling a small, flattened *C. humilis*, it does not have any of the adult growth characteristics of that species, which can grow to 150 mm tall and be quite heavily and thickly spined. *C. sp.* 'Guanillos' grows in close association with three other copiapos, an unusual situation unequalled anywhere else. It also has the most restricted distribution of any species, with only one population found even after several years of exploration in the area.

Further field investigations have not turned up other *C. sp.* 'Guanillos' populations. The plant first shown in 'Copiapoa 1996' does not match Ritter's description. He wrote that *C. esmeraldana* came from the steep coastal slopes south of Esmeralda. 'Our' plant grows in a small area 3 km north of Esmeralda. When we examined the area mentioned by Ritter we found plants similar to *C. grandiflora* which is more in keeping with his description. This being the case, the Guanillos valley plant must be something else. *C. sp.* 'Guanillos'



appears to grow only on a few hills in the Guanillos valley in association with *C. laui*, *C. grandiflora* and *C. longistaminea*⁽⁸⁾. I estimate that the single population of *C. sp.* 'Guanillos' only occupies an area of about 0.8 km², making it the most restricted of copiapoa species. Its association with *C. laui* and *C. grandiflora* is peculiar. Other *C. laui* populations have no *C. sp.* 'Guanillos' associations, as do other *C. grandiflora* sites. One possible explanation for this phenomenon is that *C. sp.* 'Guanillos' arose fairly recently as a hybrid between *C. laui* and *C. grandiflora*⁽⁹⁾. Cross-pollination of these two species in cultivation should be able to prove if this hypothesis has any validity. Other possibilities are that *C. sp.* 'Guanillos' is a new species, a relict form of *C. humilis*, a miniature aberrant form of *C. grandiflora* or a spiny northern form of *C. hypogaea*.

The most recent consensus considers *C. sp.* 'Guanillos' to be a subspecies of *C. humilis*. While this is possible, I feel more consideration should have gone into this matter rather than take the rather easy option of regarding it just another *C. humilis*.



(photo: Benjy Oliver)

▲ The plant above was found growing in a dense shrub along the foggy ridgetop south of Esmeralda. This plant is believed to be Ritter's *C. esmeraldana*. The insert shows an offset of this plant grown in cultivation for three years. This plant has since been renamed *C. grandiflora* ssp. *ritteri*. (Doweld, 2002)

▼ A plant showing *C. grandiflora* characteristics which may be what Ritter called *C. esmeraldana*.



◀ A large and healthy clump of *C. sp.* 'Guanillos'. This plant is plump as a result of recent rain.

Endnotes for chapter ?

- (1) During his later years, it seems that Ritter decided to cash in on his fame and make money from collecting plants. Collectors are always on the lookout for something new so he gave them 'new' plants, naming as species and varieties several copiapos (and other South American cactus) which were later to be sold via his contacts in German nurseries. A good example of this is his *C. columna-alba* ssp. *nuda* (now no longer given any credence), which are merely highly stressed young plants of the species. These have lost their spines and most of their wax and have a constricted apex. This form is the last stage before they die from stress. Another of his commercial names is his *C. serpentisulcata* var *castanea*, which is only the coastal form of the species, growing under the fog layer and thus having spines which are not algae impregnated.
- (2) True seedlings (plants under five years old) have been almost impossible to find in just about all populations. During 2001, some seedlings, which apparently germinated during the wet years of 1997-98, were found growing in a *C. cinerea* ssp. *columna-alba* population. Small seedlings of other species have been found after a rain but these did not survive out the year. *C. krainziana* and *C. serpentisulcata* appear to have been able to produce some seedlings over the last few decades. These seedlings are now 15-25 mm in diameter. Small plants of *C. cinerea* ssp. *columna-alba* appear on casual observation to be young seedlings however closer examination shows them to be shrunken, spineless, covered in white wax (only produced after many years) and with a well developed root system. I would estimate these to be at least 20-30 years old.
- (3) Ritter coined the name *melanohystrix* in 1980 for the spiny, mountain form of *C. cinerea* ssp. *columna-alba*. Ritter mentions that the two 'species' grow together, which already makes the name ill conceived. Examination of the habitat shows that the highest elevations have the spiniest plants, however there are also plants with shorter spines. Lower down into the valley there are more typical *C. cinerea* ssp. *columna-alba* but also some long spines forms.
- (4) Copiapos have often been grouped into sections by taxonomists to show relationships. In theory, only species within the same group can hybridize. This means that only species belonging from different groups can grow together and still retain their species characteristics. While this seems to work well to explain most associations, there are many exceptions, such as *C. grandiflora* (in the *C. humilis* group) which freely hybridizes with *C. longistaminea* (in the *marginata* group). Another problem is that some of the species may actually have arisen as hybrids between two unrelated species, such as *C. ahremephiana* being a hybrid between *C. atacamensis* and *C. decorticans* and *C. sp.* 'Guanillos' being a *C. laui* x *C. grandiflora* hybrid.
- (5) As drought increases and prolongs, copiapos die. It is usually the oldest and largest plants which die first, leaving the healthiest single headed or small densely clumping plants remaining. It appears that the *C. mollicula* population has gone through such an environmental selection process, with only small plants still surviving. While this reflects the situation of today, it does not tell us the potential that the species has for growth. Where there large, multi-headed clumps in the past? Did the species grow with long stems or were they always squat? These questions cannot be answered fully and even observations made on cultivated plants will not answer them completely because of the time span and differences in growth between habitat and cultivation.

6) Using the term ‘correct’ or ‘true’ when referring to a species is usually very misleading as it implies that one form of a variable species is ranked higher than another. Often, these terms are bandied about by collectors who have something to prove or is meant to denigrate the specimens of others as not being as worthy as their own. The following, by way of example, will hopefully show that this type of language is unhelpful and often incorrect. *C. rupestris* was named by Ritter based on what he knew at the time to be typical plants for this species. He knew it to come from along the coast just south of Taltal. Here, plants are stressed to the extreme and are often single headed or with only with about ten stems. Because of the low elevation, fog does not play a part in staining the older spines, hence these are yellowish. Further field work has shown that *C. rupestris* is much more widespread than Ritter knew, with the core population occurring south of Taltal on the hills a few kilometers inland from the shore. Here, at 200-300 m, plants (see photos, page ??) form mounds over 1 m in diameter with 60-80 heads. Because they grow at higher elevations, the spines are usually stained gray. So which is the ‘correct’ or ‘true’ species, the one the describing author knew, or the one that represents the core population for the species? To me, it should be the plants from core population, as it is here that the plants show their true diversity however some may argue that the form that was described, even if not typical, should be considered as ‘true’.

(7) *C. aphanes*, first published in 2004 in KuS, is supposedly unique in having pink striped flowers and a blackish-violet fruit. The latter is not in any way unique as many species, particularly *C. rupestris* and *C. megarhiza*, regularly produce darker fruits, depending on environmental conditions. The pink striped flowers are another matter, however most *C. rupestris* populations produce pinkish to reddish flowers. Unfortunately, the flower illustrated in their article and description is from a cultivated plant and thus its colour may be influenced more from cultural practices than from genetics. Compare this flower to the one on page ???, which is from a habitat plant of *C. rupestris* ‘Aphanes’. As far as I know, all copiapos have a yellow background colour which will always be evident in habitat plants. It seems that the authors of this species have made a serious error in considering this form of *C. rupestris* to be a valid species. This could have been easily avoided by either more field work or by consulting with others who are more familiar with the habitat and distribution of copiapoa species.

(8) The thicker neck on *C. taltalensis* contrasts markedly with the narrow, easily broken neck of *C. rupestris*, with which it is now considered to be co-specific. This is another reason why I feel these two taxa deserve separate species status.

(9) The Guanillos valley, where *C. grandiflora*, *C. laui*, *C. esmeraldana* and *C. longistaminea* grow together, has one small area where four species grow together. I am not aware of another location where four species of copiapos grow close together. South of Esmeralda there is a location where *C. hypogaea*, *C. longistaminea*, *C. grandiflora* and *C. columna-alba* grow within a few hundred meters of each other. In the Botija valley, where *C. ahremephiana*, *C. atacamensis*, *C. decorticans* and *C. solaris* grow, the plants do not mix closely and there is no location where more than three species coexist within 20 m of one another. Surprisingly, hybridization is not related to how many species grow together. Most examples of hybrids occur in areas where only two species grow together.

Copiapoas: Izcuna to Taltal

Copiapoa cinerea 'Albispina'

Copiapoa cinerea

Copiapoa haseltoniana

Copiapoa humilis

Copiapoa humilis ssp. *varispinata*

Copiapoa krainziana

Copiapoa montana

Copiapoa olivana

Copiapoa paposoensis

Izcuna to Taltal

The terrain in the Izcuna to Taltal sector is characterized by a narrow coastal plain and steeply sloping hills which can reach 1300 m within 2 km of the shoreline. A number of valleys break through the hills, however only the Quebrada San Ramon provide habitats which support *C. krainziana* which appears to be found only within its drainage basin.

The Izcuna valley (24°???) acts as a distribution barrier to a number of copiapoa species. The area immediately to the south of this valley is relatively hostile to all plants. Only *C. humilis* ssp. *varispinata* grows in this very arid area immediately to the south of the Izcuna valley. Further south, *C. haseltoniana* becomes the most abundant species, this extending all the way to just north of Taltal. This town is at the mouth of a deep valley however several copiapoa species have distributions which extend either south or north of the valley.

The climate of the Izcuna to Taltal sector varies markedly from north to south. The wettest area is not in the south, as expected, but

▼ The terrain nearing Izcuna becomes very arid, with almost no *Copiapoa haseltoniana* surviving on the coastal plain. Fog is relatively thin here and often burns off quickly in the mornings. *C. humilis* ssp. *varispinata* and a few struggling *C. haseltoniana* still survive on the lower slopes of the hills.



rather in the Paposo to El Rincon area which is near the middle of the sector. Here, fog is heaviest and steeply rising coastal hills block and concentrate the fog so that mists are regular. It also rains more than elsewhere in the sector, allowing for relatively luxuriant growth to occur in the most favorable pockets. The area at the base of the coastal hills at El Rincon contains a number of relic plant populations, including *Tillandsia trogophora* and a species of *Croton* which are not found elsewhere.

The true desert where no perennial plants grow is relatively close to the shore in this sector, usually occurring within 3 or 4 km of the coast at elevations above 1300 m. In the south near Taltal, the hills are not as high and plants grow further inland, including copiapos such as *C. rupestris*, *C. haseltoniana* and *C. krainziana*, the later of which grows the furthest inland.

Associated Organisms

The coastal hills, at least as far as 35 km north of Paposo, are dominated by *Deuterochonia chrysanthra*, *Eulychnia brevifolia*, *Oxalis gigantea* and *Euphorbia lactiflua*, which on favorable slopes can form an nearly

▼ The main street of Paposo, looking north. Here, the coastal road becomes less travelled and will often be cut by even a small rain event of only 10 mm. In the distance is El Rincon, a particularly wet area which faces southwest and is hemmed in by high hills which constrict and concentrate the fog. North of the hill, the terrain rapidly becomes arid.





▲ Taltal, as seen from the south. The large hill behind it is Mount Perales (1165 m), on the slopes of which are the southernmost *C. kainziana* and *C. haseltoniana*.

▼ Looking north up the coast from the top of Mount Perales. The valley in the mid-distance is San Ramon. The furthest headland is Punta Grande, which is 10 km south of Paposo. The bottom of the fog layer is around 500 m.

continuous shrub layer. *Deuterochonia chrysantha* is suffering the most from the long term dry conditions with few if any regeneration however the other species are surviving well at many locations.

Trichocereus deserticola was formerly more common but is now restricted to more favorable sites, such as the upper slopes of Mount Perales. Other cactus are relatively uncommon, being restricted to *Eriosyce taltalensis* in a number of forms. *Eriosyce rodentiophila* is only common in some of the southern coastal valleys such as the San Ramon.

The area between Taltal and El Rincon is noted for its periodic display of annuals after good winter rains. The most abundant annuals are various species of *Nolana*, which can, after good rains, form continuous carpets during a few weeks in early spring.

Mammals and birds are more common in this sector than in the neighboring sectors, mainly because the area supports more types of microhabitats. It also has several refuges, such as the far moister area at El Rincon, where animals can survive during droughts.

Human activity is common in the south of the sector and goes back at least 150 years. Mining and goat grazing are the main activities which have caused damage.



Copiapoa Distribution

Seven species of copiapoa are found within this sector. Most are very well known in cultivation, others are obscure and often mis-identified.

C. cinerea occurs as the widespread *C. cinerea* and the form 'Albispina', which is only found along the coast immediately to the north of Taltal. The closely related *C. krainziana* is also somewhat restricted, being only found within the drainage basin of the Quebrada San Ramon. There are at least three separate populations which differ slightly in their characteristics. *C. haseltoniana* is the most widespread, occurring from about 15 km north of Taltal to near the Izcuna valley. It grows on the coastal terraces as well as high up into the hills to elevations of at least 1300 m. *C. humilis* is a widespread species growing mainly within the fog elevations. The southernmost populations are about 20 km south of Paposo and it grows north to about the same distance. Its variety *varispinata* grows further north, extending into the Izcuna valley. The two varieties do not overlap. *C. montana* has a very limited distribution, occurring just north of Taltal in a single location. It seems to be closely related to *C. paposoensis*, which grows much further north. *C. olivana* also has a very limited distribution, being only found on one ridge however it may be much more widespread further up in the relatively inaccessible coastal hills. *C. paposoensis* has been recorded from 20 k north of Paposo to 30 k north of Izcuna but only at three populations. This may only be because of the inaccessible terrain and its high (above 800 m) habitat.

C. cinerea 'Albispina'

C. cinerea 'Albispina' is the northernmost form of *C. cinerea* which is characterized by having white spines instead of black. The spines are thinner and the stems are less robust than typical *C. cinerea*. Not all plants within the population have white spines, especially at above 120 m in elevation. *C. cinerea* 'Albispina' also tends to have thinner and more elongated stems than the species however the population is variable and some plants could fit in with typical *C. cinerea* except for their white spine coloration. Plants grow on the alluvial rubble and boulder covered slopes and do not grow up into the steep coastal hills, where it is replaced by the mountain form of *C. haseltoniana* (see pages ??? for a comparison of the various forms).

C. cinerea 'Albispina' extends from just north of San Ramon valley north to near 25°16'N. Here, it meets the southernmost population of the coastal form of *C. haseltoniana*. Near this area hybrids are

▼ Typical habitat of *C. albispina*, 5 km north of Taltal. Most plants grow among the loose rocks and large boulders which has been shed from the steep coastal hillsides.



common and there seems to be the beginnings of a transitional population which shows characteristics of both taxa (see page ??).

Sometimes the light colored plants of the *C. cinerea* within the San Ramon Valley (these grow at low elevations within the stream alluvium) are thought of as being *C. cinerea* 'Albispina' however seedlings from these plants develop brown or even black spines. Seedlings grown from the coastal plants almost always retain their white spines in cultivation.

Occasionally, *C. cinerea* 'Albispina' grows with the mountain form of *C. haseltoniana* which descend down from the upper cliffs along several steep rocky ridges. One easily visited area along the coastal road is at 25°20'N. This area also contains some hybrids.



▲ Some of the variation seen in *C. cinerea* 'Albispina'. All of the boulders have tumbled down from the steep coastal hillsides. The plants with more compact clumps are generally surviving much better than those with a more open growth habit⁽⁶⁾.

◀◀ *C. cinerea* 'Albispina' (foreground), growing with what appears to be a hybrid with the mountain form of *C. haseltoniana* (mid-distance). Note how the stems are larger and the new spines are yellow, later fading to a pale grey.

▼ *C. cinerea* 'Albispina' x *C. haseltoniana* (mountain form), growing near 25°17'S.





C. cinerea ssp. *cinerea*

C. cinerea is characterized by having white apical wool and black spines. While most plants in the north of the range have black spines, some populations south of Taltal tend to have brown to tan colored spines. Most *C. cinerea* eventually develop some branching. Clumps can have up to 35 heads but most plants usually have from one to five. Stems are covered with a thick coat of reflective wax which gives the plants a white appearance. The wax eventually peels off of the lower stems, exposing the bark which is a reddish-orange to brownish colour. Often the bark is coated with algae which give it a blackish coloration. The rib count is usually less than on the closely related *C. cinerea* ssp. *columna-alba*, which grows further south. The number of spines generally varies from three to five however the most attractive plants (see photo, left) have only a single spine. When collection of copiapos from Chile was common, many single spined plants were brought into cultivation, giving collectors the impression that these for 'the true' *C. cinerea* when in actuality, they compose a very small minority of plants. Often seedlings from single spined individuals do not show this feature (see photo, page ???)

The populations of *C. cinerea* are stable, at least in the more favorable locations. In all large populations this species is monotypic,

▲ A healthy *C. cinerea* showing abundant white wool and white wax going down the sides of the stems. Unhealthy plants only have wax near their pinched apex which typically does not show much wool.

▼ 'Cinerea valley', east of Taltal, contains the largest known population of *C. cinerea*. We have estimated the population here at between 250,000 and 400,000 mature plants.



being the only copiapoa species in its habitat however occasionally, but only along the very edges of the population, there may be another copiapoa present. One example of this is east of Mount Perales where *C. cinerea* grows with *C. rupestris* in a slight overlap of populations.

In the southern part of its range, *C. cinerea* appears to form a transitional population with *C. cinerea* ssp. *columna-alba*. We still believe that these taxa deserve a separate taxonomic rank, if only because the seedlings are quite distinct. Seedling characteristics are seldom given any weight by taxonomists but I believe this can be a useful diagnostic feature. Further work on seedling characteristics should be able to identify the transitional populations as well as the mountain *C. cinerea* populations.

C. cinerea hybrids are occasionally found. We have noted hybrids with *C. krainziana* (Ritter's *C. scopulina*, which is relatively uncommon in habitat), *C. cinerea* ssp. *columna-alba*, *C. haseltoniana* (quite rare, only seen with the mountain form) and *C. rupestris*.



- ▲ *C. cinerea*, in its most spiny mountain form, growing at 950 m on Mount. Perales.
- ▲ A very stressed *C. cinerea*. This plant has grown very little over the last decades, as indicated by how far up the ribs the bark has advanced. Note how thick the wax is where it meets the bark. The spines have all been shed and no new growth has emerged from the constricted apex for a long time.
- ▼ An exceptionally compact *C. cinerea* on Mt Perales.





C. haseltoniana (includes *C. gigantea*)

C. haseltoniana is characterized by its yellow wool, light colored spines and large clumping habit. The stems are heavily wax covered which often gives them a bluish coloration.

In 'Copiapoa 1996' we tried to differentiate *C. haseltoniana*, *C. 'gigantea'*, *C. 'eremophila'* and *C. 'tenebrosa'*. Further field work proved that this was not warranted and was more confusing than clarifying. Today, I believe that it is better to consider all the clumping, yellow or orange woolled copiapoas north of Taltal as forms of *C. haseltoniana*. The often visited plants near the coastal road all the way to 40 k north of Paposo are best called *C. haseltoniana* (coastal form). The large bodied and often single stemmed plants from near 25°16'N which we called *C. 'gigantea'* in 'Copiapoa 1996' seem to just be a large mostly single stemmed form of *C. haseltoniana*. While often single stemmed, it was noted that during the wet year of 2001, many offsets on the lower stems were being eaten by mice or rats. *C. haseltoniana* 'Gigantea' grows mainly on rubble covered slopes among rocks and small boulders which is an ideal habitat for rodents. Perhaps the single stemmed nature of this form has more to do with rodent nibbling the stems during favorable years than genetics. Further study of seedling development over the next decade should prove if this is correct.

- ▲ *C. haseltoniana* growing at 250 m. This plant is healthy as exhibited by the wax layer which descends down to nearly the base of the stems. The extent of the white wax down the stem is an easy indicator of how well plants have been growing. Photographed during the wet year of 2001.

(photo: Ricardo Keim)

- ▲ *C. haseltoniana*, growing about 10 k north of Paposo. Large clumps like this are common.

- ▼ The 'Gigantea' form of *C. haseltoniana* with basal stems erupting through the epidermis. Note how the new stems appear very different from the mature plant.



In 'Copiapo 1996' we used *C. 'tenebrosa'* to refer to the yellow woolled plants growing on Mt. Perales. Further investigations has shown that this plant should best be regarded as the southern mountain form of *C. haseltoniana*. In its typical form it has longer and more slender stems as well as darker spines than the coastal form. Often, it is spinier but there are some populations which can become almost spineless. This spineless form (see page ???) grows at lower elevations than the more spiny plants, often at the lower or coastal limits for this mountain form. Interestingly, seedlings are often less spiny, tending to shed their spines if stressed and grown hard. Plants in the core areas (at 800 m and above) have the longest and spiniest stems and form the largest clumps.

The *C. 'eremophila'* of Ritter referred to the northern mountain form of *C. haseltoniana* which grows inland and north of Paposo at elevations of up to 1300 m and extend northward on the steep hillsides for at least 30 km. In this book, *C. haseltoniana* (mountain form) and *C. haseltoniana* are used; I hope this makes it less confusing for readers. The higher elevation plants in the north have longer and more abundant spines, thicker stems, and are less offsetting than the



- ▲ The mountain form of *C. haseltoniana* growing near of Paposo. At 1100 m, the plants are normally above the fog layer.
- ▼ North of El Rincon, *C. haseltoniana* gradually become stressed and thin out, especially along the coastal road (looking north). Much healthier plants grow higher up the hillsides, reaching 1300 m.





- ▲ The mountain form of *C. haseltoniana* growing among rocks and scattered mostly dead shrubs. Plants produce seed over a long period without any apparent flush of flowers.
- ▼ The habitat of the mountain form of *C. haseltoniana* which grows above Paposo at 1100 m. Each of the faint dots on the mid-distance hillside is a clump of *C. haseltoniana*. Note the lack of other plants, especially *Eulychnia breviflora* which is so abundant at lower elevations in the fog belt.

coastal form. Plants at the highest inland locations grow much like *C. cinerea*, with few offsets and stout upright stems. As elevation decreases, the plants begin to look and grow more like the *C. haseltoniana* from along the coast.

As a general rule, the higher the elevation, the spicier the plant and the darker the spines. In the south, higher elevation plants also have thinner and longer stems. The southernmost populations (*C. 'tenebrosa'*) are bluish and have much longer and thinner stems than the northern mountain populations (the *C. 'eremophila'* of Ritter).

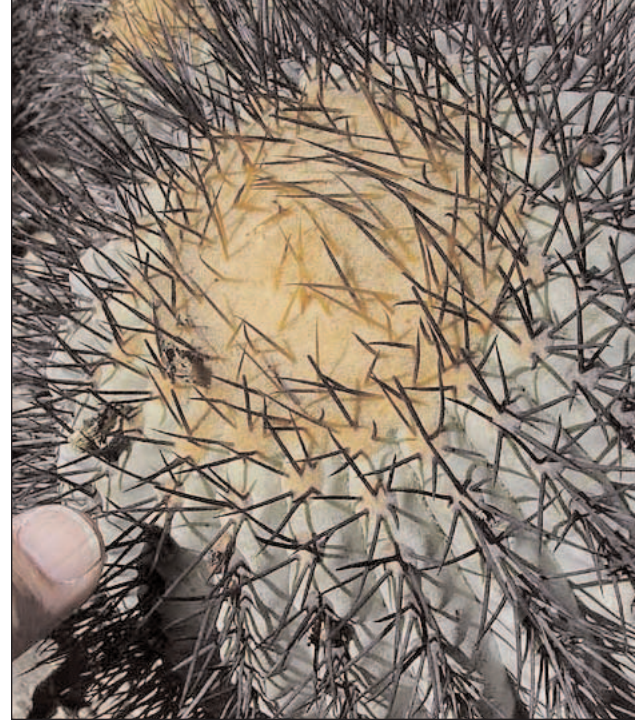
The southern mountain form of *C. haseltoniana* hybridizes with *C. krainziana* (see comments page ??) and very rarely, with *C. cinerea* at the southernmost extent of the range. This taxon also shares the same habitat as *C. rupestris* with which it may form hybrids.

Most populations of *C. haseltoniana* are healthy, even at the highest elevations where plants were found growing at up to 1350 m. Many plants grow above the normal upper limit of fog and are totally reliant on rainfall for survival. *C. haseltoniana* do not grow within the main fog zone (400-600 m) unless it is on sites that face directly north or inland in a 'fog shadow' which is protected from direct contact with fog. Small, single headed plants are not common and small plants under 25 mm are very rare. This indicates that while the adult



population may be healthy and surviving well the reproduction necessary to sustain the populations in the long term is not occurring.

C. haseltoniana almost always grow alone. In the upper San Ramon valley, the mountain form of *C. haseltoniana* overlaps slightly with *C. krainziana*, occasionally forming interesting hybrids (see page ???) The same populations also overlap slightly with *C. rupestris*, which grows more inland than *C. haseltoniana*. South of Paposo, *C. humilis* sometimes descends down onto the coastal plain where *C. haseltoniana* forms pure stands. Higher up the mountains, the two species seldom meet as *C. haseltoniana* tends not to grow in the foggy habitats preferred by *C. humilis*. In the far north of its range above 25°40'N, *C. haseltoniana* grows with *C. humilis* ssp. *varispinata*.



▼ *C. haseltoniana* (mountain form) often form large clumps which can reach 3 m in diameter.

▲ Apex of *C. haseltoniana* (southern mountain form)





▲ This form of *C. humilis* grows at low elevations well below the fog layer. Typically, plants from low elevations have spines which are thinner than those on mountain forms.

▼ Photographing *C. humilis* at 700 m above Paposo. Plants grow on the bare hilltops but also descend the steep slopes where they grow among *Eulychnia brevifolia*, *Euphorbia lactiflua* and *Oxalis gigantea*.

C. humilis ssp. *humilis*

C. humilis is one of the small growing soft bodied copiapoas that does not form extensive populations which dominate the landscape. The stems can be spiny but often the smaller ones are more bristly. Plants develop a thick taproot which has a narrow, easily broken neck connecting it to the stems. The ribs are indistinct and the tubercles are prominent. The epidermis is dark green to brownish-purple and never wax covered. Plants expand with rain and contract markedly with moisture stress. Even when fully expanded, the bodies are somewhat soft. Fully stressed plants are very soft and appear deflated.

C. humilis ssp. *humilis* has been found growing as far north as Quebrada de la Plata (24°43'S). In the south, it grows to only about 20 km south of Paposo. As a general rule, the typical form which grows north of Taltal does not grow with the coastal form of *C. haseltoniana*. *C. humilis* is a plant of the fog zone, preferring to grow with *Eulychnia brevifolia* and *Euphorbia lactiflua* while *C. haseltoniana* (coastal form), which shares its general habitat, prefers the less foggy, lower elevations or the drier, more inland and elevated habitats (mountain form).

Plants of *C. humilis* ssp. *humilis* are still plentiful in the more favorable sites, especially where they grow among rocks that protect



them from guanaco and donkey attack. In many locations the plants consist of compact stems showing juvenile characteristics instead of the mature form. Most visitors wishing to see *C. humilis* in habitat usually do so along the road inland from Paposo as this is the only easy access to the fog zone vegetation. Other habitats for *C. humilis* are harder to access, however some plants grow near the costal road at the base of the coastal hills among *Eulychnia brevifolia*. These plants all seem to be young and appear to have colonized this habitat in recent times, most likely as a result of the drying environment making it less crowded with herbaceous plants.

One definite hybrid of *C. humilis* X *haseltoniana* was found growing in the Q. de La Plata. This unexpected and seemingly unlikely hybrid shows that it may be possible to hybridize just about any copiapoa species.



▲ A large *C. humilis*, growing above Paposo. The dried soil and debris has been carried between the heads by ants, which sometimes make their nests at the bases of copiapoa.

▼ *C. humilis*, growing above Paposo (650 m), near the type location. Old plant, as shown on the left, are now hard to find because the heads have almost all been knocked off by guanaco and donkeys. The clump on the right shows differing levels of regrowth, the oldest have thick and long spines, the youngest have thin, almost bristle-like spines.





▲ *C. humilis* ssp. *varispinata* growing out from a rock crevice. Plants may take on a reddish coloration, especially when stressed. Note the gap between the plant and the rock, caused by plant shrinkage during the preceding dry period.

▼ The subspecies name *varispinata* is justified when comparing these two old specimens.

C. humilis ssp. *varispinata*

C. humilis ssp. *varispinata* differs from the typical species by having smaller greenish bodies. Some, in stressed sunny positions nearer the coast, can be reddish. Plants grow to about 75 mm in diameter, sometimes offsetting to form clumps with ten or so heads. Stems seldom get higher than they are wide but this may be due to predation of stems by guanaco and donkeys. As the name indicated, the spines vary substantially from plant to plant.

Ritter reported this taxon as growing 50 km north of Paposo in the coastal mountains. Field investigations has shown it to be relatively widespread, extending along the coast from as far north as Miguel Diaz (24°33'N), then south to 24°41'N, an extent of 15 linear kilometers. Plants grow from 100 m up to almost 1000 m (on the top of Izcuna peak where it grows with *C. solaris*). *C. humilis* ssp. *varispinata* grows among rocks or in loose rubble and seem not to be as particular to aspect or slope steepness as other copiapos, being found on all exposures in almost equal numbers. In the southern areas of its range, *C. humilis* ssp. *varispinata* grows with the northernmost populations of *C. haseltoniana*. In the north, *C. humilis* ssp. *varispinata* grows with *C. solaris* and at one location, with a few *C. atacamensis*. Between the Izcuna and Botija valleys, it grows with *C.*





paposoensis. No hybrids have yet been found.

Ritter (who first found this plant in 1968), commented that it was difficult to believe that the plants growing at high elevations were the same species as those from near the coast. We found this not as obvious, perhaps we climbed and examined a different population gradient. Plants have a swollen taproot and will produce new offsets if stems are damaged or removed. Plants at higher elevations were spinier than those near the coast but this applies to all *copiapoa* species. Many dead plants are evident at the lower elevations and the condition of live plants, especially those on the sunnier, north and west facing slopes, is poor. Plants growing in shady positions and those at higher elevations are faring much better. Considering the soft body of *C. humilis* ssp. *varispinata*, it is surprising that the plants are surviving so well among supposedly hardy *C. solaris*, *Euphorbia lactiflua* and *Eulychnia brevifolia*, most of which are dead or dying. On the dry hilltops above the Izcuna valley, *C. humilis* ssp. *varispinata* and *C. solaris* are the only perennial plants still surviving. With this in mind, *C. humilis* ssp. *varispinata* must be considered as endangered from increased aridity.

Plants have been found with the occasional fruit during winter, suggesting that they are not strict late spring flowerers. New offsets from the taproot do not initially appear green and look very different from the adults. Coupled with the differences between high elevation and lowland plants, this species shows remarkable variation in spination and colour, justifying Ritter's species name.

Plants in cultivation continue to keep their green colour but elongate more in stem length. A habitat collected plant grown eight years in cultivation showed no changes in spination or stem diameter.



▲ The habitat of *C. humilis* ssp. *varispinata* is large and variable. Here, two plants grow in the foreground on alluvial deposits. The steep hillsides in the distance are also home to *C. tenuissima*.

✦ These two *C. humilis* ssp. *varispinata* are protected from guanaco and donkey predation. Spinier plants may be those which have never been dislodged from their swollen taproot.

▼ A typical *C. humilis* ssp. *varispinata* growing at the base of a large rock where it is offered some protection from guanaco digging and also benefits from runoff.





- ▲ *C. olivana* grows on steep slopes with *C. gigantea*, *Euphorbia lactiflua* and *Oxalis gigantea*. Note the steepness of the slope in the background.
- ▲ Plant photographed during 2005 after good winter rains. Note how firm and plump the plants appear compared to those below photographed in 2004.
- ▼ Some stressed plants shrivel and look somewhat like *C. sp.* 'Guanillos' (see page ???).



C. olivana

C. olivana in habitat appears somewhat like a spiny form of *C. mollicula* however the body is softer when stressed. Plants ranged from single stems to clumps of four heads. The largest stem was about 80 mm in diameter. Most plants appeared to be regrowths from older roots.

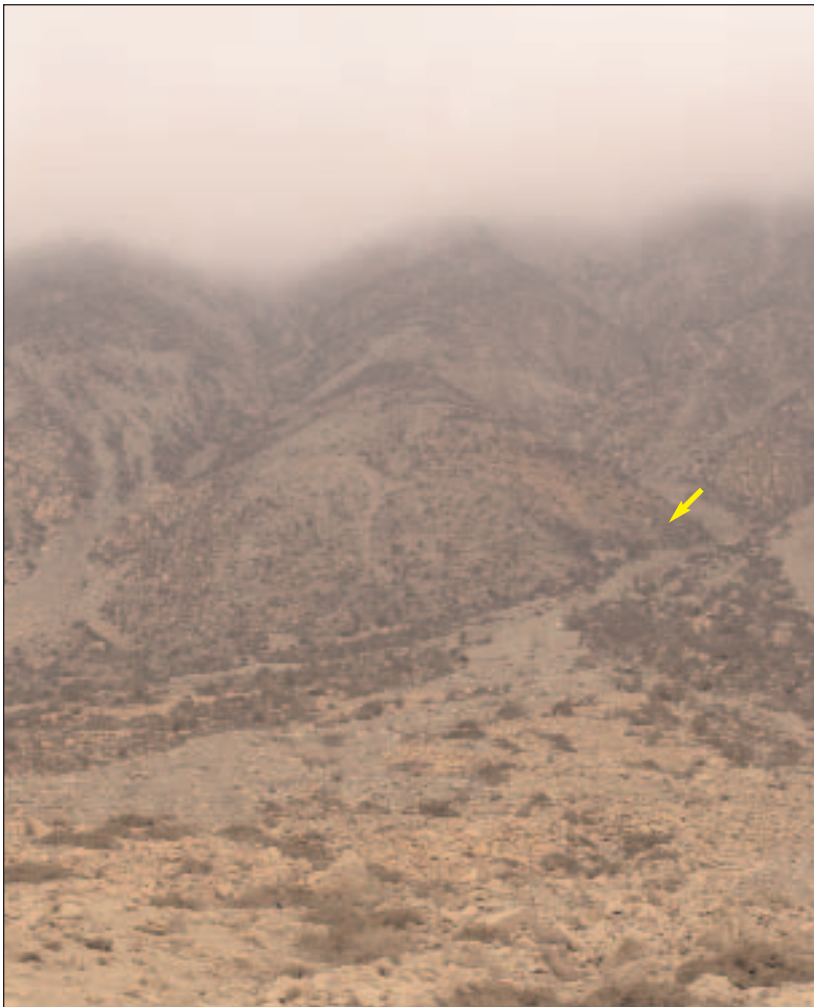
C. olivana is recorded by Ritter as growing as an isolated population near Caleta Oliva, north of Taltal. Several attempts to discover this population proved unsuccessful until the search was extended north by a few kilometers. Here, (25°15'03"S 70°25'20"W) it occurs down to 200 m on solid rock faces just above the rubble covered slopes. Meregalli & Doni (1991) reported that it occurs from 150-500 m in elevation on cliff faces. The plants we found were growing on steep slopes in mostly open ground or sometimes at the base of large rocks or in rock crevices. Because we only examined plants growing at the lower elevations we are unable to discuss how the plants look higher up in their core population, where they may grow larger and show much more variable characteristics.

Signs of recent flowering were not evident except on one plant which had no roots as it had been knocked off by guanacos. No young plants were found, suggesting that this population, which would be at the lower and more stressed edge of its range, is composed on only old plants or reshoots from large taproots.





◀ A large *C. olivana*. Older plants develop definite ribs as opposed to just tubercles. This plant has been heavily infected with borers, note the frass near my fingers.



▶ Looking east from the coast road towards the habitat of *C. olivana* (yellow arrow). No plants were found growing among the alluvial material at the base of the hills, nor on the cliffs to the right of the canyon. The bottom of the fog layer is at about 600 m.

▼ Two *C. olivana* growing on the tan colored granite. The rock is very fractured and unstable.





C. krainziana

C. krainziana is characterized by its numerous thin white spines, making it the most unmistakable of *Copiapoa* species. Spines vary in thickness, length and straightness. Plants in cultivation are often have curly, soft spines, these do not reflect typical plants in habitat.

In 1996 we knew of only two populations of *C. krainziana*, the northern population growing in the hills and the valley population growing in the middle reaches of the Quebrada San Ramon. A third distinct population (the southern population) was discovered while walking from the summit of Mt. Perales down into the San Ramon valley during 2001.

C. krainziana prefers north facing slopes however populations, which grow further inland where the environment is drier, grow on south facing slopes. It does not extend above the fog zone, where it is replaced by the mountain form of *C. haseltoniana* with which it occasionally forms hybrids (see page ??), especially towards the inland. As a general rule the lowest elevation plants, especially those somewhat sheltered by large rocks or shrubs, have the softest and whitest spines.

The health of *C. krainziana* populations is far better than for almost all other *Copiapoa* species. There are very few dead or dying plants in any of the populations. Small plants are not rare, with

▲ Looking up the San Ramon valley at around 450 m elevation. Plants in this population (the ‘valley population’) are often old and have taller stems which become spineless with age. The spines are usually whiter than plants which grow nearer the coast or in the foggier areas higher up the hillsides.

▶▶ A *C. krainziana* from the southern population growing on the slopes of Mt Perales (elevation 650 m). Most of the older stems have spines which are heavily stained by algae.



'seedlings' down to 15 mm being sometimes found in rock crevices.

During 2001 (June) *C. krainziana* habitats supported large populations of mice which were feeding off of the ripening fruits and buds. No fruit was collected and we saw live mice among several plants during daylight hours when they would normally be inactive. During August of 2002 the same populations had no evidence of any mice, even though it was an El Nino year. During that year there were many herbaceous plants, including many *Alstroemeria* sp. No *C. krainziana* fruit was evident during 2002 but plants did show signs of new spines and all the stems were fully turgid. During May of 2003 the plants were in good condition and were flowering and abundant with fruit. No signs of mice or any predation on fruits was evident. During September 2004 there was only a few old fruit evident. In September of 2005 (after a wet winter), plants showed no signs of flowers or fruits.



▲ A plant in the valley population. The younger stems closer to the ground are whiter than the older and more elevated stems.

◀ A typical *C. krainziana* (right) growing next to a *C. krainziana* x *C. haseltoniana*. Hybrids are not uncommon, especially at higher elevations.

▼ Plants with thin, flexible spines such as this one are relatively rare in a population which is made up mostly of more robust and shorter spined individuals.





▲ Typical *C. montana*. Note the old flowers among the apical spines.

C. montana

C. montana is one of Ritter's 'minor species', having only been found at one location. We attempted to find this locality and we found plants which we believe are his population even though they differ significantly from plants labeled as *C. montana* in cultivation. We believe these are mis-identified.

C. montana is a densely spined, weak ribbed small growing species which has a large tap root. The body is somewhat soft, however this was during a dry season. Plants appear somewhat like a robust *C. humilis* but may also be related to *C. paposoensis* from further north. The inaccessibility of the species has meant that it has apparently not been visited by other copiapoa enthusiasts since Ritter's original discovery. Further field work in the area to determine if there are more and varied populations is required.

This population grows just north of Taltal on the very top of the coastal hills (750 m). The habitat is similar to that preferred by *C. humilis* and the plants look and grow like spiny versions of that species. The body is slightly soft but this depends on the moisture state. Plants grow in a dense but limited population which does not extend inland further than 50 m from the foggy ridge tops. For much of the year, this area is bathed in dense fog for the majority of the day,

▼ From the habitat of *C. montana*, looking north. This west facing slope and ridge. The coastal road is visible some 750 m below.



only clearing briefly in the mid-afternoon. To the east of this population, the land slopes down to a less fog bound valley where the mountain form of *C. haseltoniana* grows. *C. montana* appears not to hybridize with *C. haseltoniana*.

Flowering on *C. aff olivana* extends over a long period, with fruit and flower buds being present along with many old, dried flowers. Because of the high fog levels, the habitat supports a thick population of *Euphorbia lactiflua* and *Eulychnia brevifolia*, along with many non-succulent shrubs and annuals.

Because of its isolated location, *C. montana* is not endangered from habitat destruction or collecting. Guanaco and donkeys have damaged plants, knocking off the larger heads to chew at the bases as well as digging around the plants in an attempt to feed off of the thick taproot. The spiny nature of this species protects plants and it is still possible to find mature specimens growing among loose rock and soil. We first found this plant in 2003 growing in a small habitat at 800-900 m. The population is dense but limited to about 1km².

Ritter (1980) illustrates a plant of *C. montana* but this is of a bloated plant grown in cultivation and quite different from those found in habitat.

C. montana grows near to a population of *C. haseltoniana* so perhaps hybrids can be found.



C. montana is not as variable as many other copiapos however much of this is masked by the dense spination which hides the stem features. Old plants develop distinct ribs.

▀ The habitat of *C. montana*, looking west. Just beyond the rise, the ground drops of very steeply. Most plants have not been damaged by guanaco or donkeys, most likely because there are other more palatable plant species growing in this damp environment.

▾ *C. montana* has a thickened taproot. This large plant has less spines than most, most likely because the stems are regrowths from the thick root. Compare this plant with the older ones in the upper picture.





▲ *C. paposoensis* has a green epidermis even though it grows in full sunshine throughout the year.

▼ An old *C. paposoensis* grows out from a rock crevice at 1350 m. The neighboring hills and slopes are quite barren and dry as they are well above the upper limit of the fog layer.

C. paposoensis

Ritter found this plant growing 20 km north of Paposo at elevations of 1100 to 1300 m. We made several attempt to get to this population before succeeding in finding an area which matches Ritter's location. Plants were found growing at atop the steep coastal hills where they flatten out somewhat. Toward the inland area is very barren, being well above the upper level of the fog. Further inland (even just 50 m) where the land flattens out to a walkable slope, there are no plants. The habitat is in full sun for the whole afternoon and is also quite windy. We visited the site several days after 2 mm of rain fell along the coast at Paposo and the soil was damp (down to 80 mm), suggesting that more rain falls at this site than at lower elevations.

C. paposoensis grows at least up to 1350 m in elevation. Plants became more abundant at 1250 m and formed a dense but narrow population on the edge of the west facing slope. At lower elevations (1250 m) the mountain form of *C. haseltoniana* grows in a narrow band down to about 1000 m where the first eulychnias and *Euphorbia lactiflua* indicate the upper fog level. The lower limit of *C. paposoensis* is not known because of the inaccessibility of the steep slopes, nor is it known how far south or north this plant extends along the hillsides.

C. paposoensis has a moderately hard (after recent rain) green body





which is densely covered in long, thick spines. Superficially, plants resemble a spiny *C. montana* or *C. humilis* in overall appearance⁽⁸⁾. Plants appear not to elongate, being wider than they are high. Plants have a very thick taproot with a narrow neck but this neck is not evident on plants which have been repeatedly damaged by guanaco attack.

Because of its isolation,



▲ *C. paposensis* growing out from a damaged root. New shoots from roots show a bristly juvenile growth form similar to those seen on *C. humilis*.

↖ Habitat of *C. paposensis*, looking north.

↙ Old plants of *C. paposensis* can be taller than they are wide.

▼ The root of *C. paposensis* is very thick. This plant appears to have been damaged and has resprouted with several new stems.



Endnotes for chapter ?

(1) Because very little data on climate is available in the locations where copaiapos grow, I placed a data logger (device for remotely measuring environmental data) within a large clump of *C. haseltoniana* (southern mountain form) on Mt Perales (elevation of plant was 1050 m). It was there for over 16 months, recording temperature and relative humidity every 20 minutes. The data showed that temperatures were not extreme, with the lowest recorded temperature (???) recorded on ??? and the highest (???) on ???. The relative humidity data showed, by indirectly measuring a rapid rise in humidity when fog (or rain, which is very rare) occurred. for the ??? days, only ??? days show a rapid rise in humidity, hence the assumption that these days had periods when fog penetrated to this elevation.

(2) When climbing about the hillsides (mostly above 200 m) the importance of *Deuterocohnia chrysantha* in holding together steep hillsides can be appreciated. Even though now almost all the plants are dead, the dried clumps often still are the only firm footholds available. The thick roots are also important in holding fragile fractured rock and soil together but many of the roots are now so decayed that they no longer act as anchors for the soil. Copiapoas, particularly *C. rupestris*, can sometimes be found growing out of the upper (dies first) sides of clumps, most likely having become established only once those rosettes had died. Reproduction in *deuterocohnia* is today non-existent. In my travels, I have only once found one plant which consisted of a single rosette. This was growing among boulders at the bottom of a rocky ravine, which is not a normal habitat for this sun-loving species.

(3) First impressions on the damage done by goats are correct, they eat out certain plants, destroy the soil and cause erosion. Careful examination of areas near heavy goat grazing (sometimes for over 100 years) seems to indicate that they are favorable to copiapoa survival, at least in the short term. By eating other plants, they reduce the competition for water, light and nutrients. The soil destroying aspect is another matter, as this can cause the loss of habitats suitable for seedling development but as copiapoas are long lived plants with extensive root systems, this is not an issue in the first one hundred years of so of goat grazing. In rocky areas, there are plenty of crevices and here it seems copiapoa seedlings have become established over many decades, leading to a preponderance of single headed plants in areas heavily grazed by goats. Since they are normally not eaten or damaged (with some exceptions in cases of severe drought), copiapoas become the dominant plant in the landscape, along with a few poisonous or totally inedible shrubs.

(4) There is a clear relationship between spine colour and elevation. Plants growing at low elevations near the sea usually have light colored spines. Plants growing higher up in the fog layer (400-800 m) have dark spines. A close examination of such spines (see photo, page ??) show that the spines become stained from algae which grows on and within the older spines. Plants which grow at high elevations or quite far inland, where fog seldom penetrates, have light colored spines. Even species with white spines, such as *C. krainziana*, show the same feature, with plants at the lowest elevations (along the bottom of the San Ramon valley) having clean, white spines, while plants growing high up on the ridges having dirty, dark gray spines.

(5) The *C. cinerea* complex taxa (*C. haseltoniana*, *C. cinerea*, *C. columna-alba* and *C. krainziana*) grow in single species stands. Such mono typical stands can be quite frustrating when looking for other species. Even though there seem to be suitable micro habitats for other species (such as for *C. humilis* or *C. hypogaea*), none have ever been found. It is only along the overlapping edge where other species begin to occur. River valleys, such as the San Ramon, also show mixed populations, but this reflects the fact that seeds are washed down by rains and grow in

the alluvials among other transportees.

(6) Large, open grown and long stemmed copiapoas are suffering much more from drought stress than single headed or compact clumping specimens. In many cases, the majority of the population has been culled by drought, leaving only single headed plants or compact clumps. In less stressed sites open clumps often show vigorous re-sprouting from the bases of the elongated stems which I interpret as an attempt by the plant to become more hemispherical, thus reducing the surface to volume ratio. Only in the core area will plants show the growth form that was typical for that species. The best example for this is with *C. rupestris* (coastal form) where the great majority of plants along the coast are single headed or small clumps with up to six or so heads. The stems are squat with minimal elongation. In the core area higher up on the coastal hills the plants can be over to 1m in diameter with individual stems reaching 600 mm in length. But which plants represent the future direction of that plant's growth form? This would have to be those plants along the dry coast which are adapting to survival in an ever increasing arid environment. Because every visit to habitat is merely a snapshot in time, it is dangerous to draw too many conclusions, however in regards to stress, it seems that we have enough evidence to conclude that the plant's growth form is changing rapidly and only those individuals what can adapt (see page ??) are surviving.

(7) The easiest way to prove that fog is not important to copiapoas growing at higher elevations it to point out that those plant growing in the fog always have heavy lichen encrustation on their older spines. The nearer to the heaviest fog (usually 500 m), the more luxuriant the lichen growth. Plants growing above 850 m usually have no lichens on their spines. This means that there is no regular fog above that elevation (also see footnote, page ??)

(8) The question of whether *C. paposoensis* is a form of *C. humilis* need to be considered. If this were true, the two plants would not grow together as distinct and unique populations, instead, there would be an obvious transition with numerous hybrids. This is not the case. At the Botija Saddle location, *C. humilis* ssp. *varispinata* grows together with *C. paposoensis* without clear intermediates. Ritter also pointed this out in his assessment of the two taxa, based on both plants growing together 20 km north of Paposo. It may be that the current lumping of *C. paposoensis* in with *C. humilis* is based on incorrectly labeled cultivated plants rather than on habitat considerations.

Copiapoas north of Izcuna

Copiapoa ahremephiana
Copiapoa atacamensis
Copiapoa decorticans
Copiapoa solaris
Copiapoa tenuissima
Copiapoa tocopillana
Copiapoa aff. *paposoensis*

North of the Izcuna valley

The Izcuna valley, while not a major physical barrier, is the boundary which defines the southern and northern limits of a number of copiapoa species. What we see today in the very dry northernmost sector is only a snapshot in time reflecting a dynamic copiapoa population. It is evident, even from the casual observer, that the northern populations are declining from lack of water. I refrain purposefully from using the term drought, as this suggests a temporary period of below average rainfall rather than a new and continuing situation of lower than historical rainfall. Today, from about 25°N (about 15 km north of Paposo), only relict discontinuous populations of copiapoas remain. Relict populations are characterized by a preponderance of mature to old plants as well as many dead remains.

The area north of the Izcuna Valley has a more broken topography than further south. Near Antofagasta, continuous high hills give way to a wide coastal plain. North of Antofagasta, the Cerro Moreno stands as a single, flat topped mountain in a side plain, providing habitat for a large population of *C. atacamensis*. North of this, there are no more ideal habitats for copiapoas and what survives, does so under very harsh and dry conditions.

▼ Looking north, towards the Izcuna Valley. The area to the south still supports scattered *C. haseltoniana* in a very stressed condition. Note how bare the coastal terrace is when compared to further south.



Associated organisms

All types of plants are stressed in this sector. In most areas, there are no longer enough seeds in the ground to germinate and grow during the very rare wet years so annuals are extinct. Even if there were excellent rains over several years annuals would be very sparse at best or they would have to re-colonize the area from further south or north from the few relict 'oasis' where healthy populations still survive (such as from the top of Cerro Moreno and from the upper Botija Valley). Some perennials still cling to life on the most favorable areas, these usually being steep southwest facing coastal slopes where fog banks up and mists are common enough to support plant life.

North of the Iszuna Valley, the most dramatic relict from the wetter past are the forests of *Eulychnia brevifolia* which can be seen on the higher hillsides. From a distance they appear alive but closer inspection reveals that they are all dead or nearly so.

Because there are so few plants, animal life is restricted to very few species, none of which are obvious or easy to find. The mammals present are those which can survive on the marine environment, such as the desert fox. Guanaco have all died out or migrated elsewhere. Their traditional trails, which are still visible on the dry bare interior hills, are no longer used, mainly because there is not enough plant



- ▲ *C. solaris* is the most widespread copiapoa species north of Izcuna. Here, it grows above the Botija Valley, looking north. Most of the dark dots on the mid distance hillsides are more *C. solaris*.
- ▼ Inland of El Cobre, looking northwest. Here, the hills are very desolate with only a few *C. solaris* in the valley near where the fog ends. This type of arid landscape continues northwards for over a thousand kilometers.



growth along the route. The last guanaco on Cerro Moreno were reported in the 1960, and the remains of their dust baths and dried excreta are still visible.

One benefit of the removal of guanaco (and donkeys if they were ever so far north) is that sites with plants now have a chance to regenerate in a limited fashion. An example from the top of Cerro Moreno illustrates this point. After the last guanaco died (or was shot), plants began to grow without being grazed. *Eriosyce recondita*, a favored plant of guanaco, is now quite common on the south facing upper slopes and shows no signs of being nibbled. About fifteen years ago an experimental fog water collector was constructed near the top of the mountain and a few tree seedlings, such as *Schinus molle* (Chilean pepper tree) were planted. After a few years the fog collector collapsed however the small trees are still surviving. The tallest is about 1.5 m tall and it catches sufficient fog to wet the soil near the tree's base for moss grow. There are also a number of other plants in this miniature oasis created by the fog collection from several small trees. With no guanaco to destroy it further plants may grow and flourish. But this exceptional example of survival and recolonization is not indicative of the region as a whole.

▼ From near the top of Cerro Moreno, looking south across thousands of *C. atacamensis*. Within the very arid landscape shown on the opposite page there are a few oases continuing abundant life. The best known north of Izcuna is the summit of Morro Moreno, which, at around 1000 m, is in the fog zone for most days in the year. *C. atacamensis* grows here in abundance.



Distribution of copiapoas

Only five species of copiapoa grow within the Iszuna to Tocopilla sector. *C. ahremephiana* and *C. decorticans* have the most restricted distribution, being only found within the Botija valley drainage. *C. tenuissima*, the smallest growing of the species, has a larger range but because of its small size and difficulty in finding specimens, it may be much more widespread than thought. Currently, it is known from Botija Peak north to at least El Cobre however it may still survive in more favorable microhabitats further north, where very little exploration has been conducted. *C. tocopillana* has been recorded from half way between Antofagasta north to Tocopilla but only in a very few localities. This is because of the rugged terrain and because this species seems only now to survive at elevations above 1000 m. Because there are no roads leading up into the hills, exploration needs to be on foot starting from the near sea level coastal road. The coastal cliffs in this area are also very steep, making an ascent into the habitat very difficult and slow. All of the species so far mentioned grow within 5 km of the sea.

C. solaris has the largest distribution, growing from just south of Izcuna to 60 km north of Antofagasta, an extent of 170 km. The southern population in the upper Botija valley is by far the healthiest and most abundant. Next comes the large population inland from El Cobre. Here, most plants are now dead, appearing to have done so within the last few decades (see page ???). North of this, there appears to be a break of at least 120 km before the northernmost population is encountered near Naguayán. Here, only a few percent of the plants are still alive. The further north, the fewer live plants. The northernmost population seems only to grow at low elevations at the base of the hills just inland from Route 5.



▲ A healthy *C. ahremephiana* growing at 400 m elevation. Very few plants in habitat are as healthy as this specimen.

▼ *C. ahremephiana* with *C. decorticans* (left foreground), growing at 500 m above the the Botija Valley.

C. ahremephiana

(The *C. veriispinata* of Copiapoa, 1996)

Incorrectly identified by us in 1996, this long known plant has since been named *C. ahremephiana* by Taylor and Charles (Cactaceae Systematics Initiatives 13: 15, 2002). For those not familiar with British quaintness, 'ahremeph' is the phonetic spelling of RMF, standing for Roger M. Ferryman, who first introduced this plant into collections in the UK as *Copiapoa* sp. RMF53.

C. ahremephiana has small stems to 100 mm diameter and forms clumps to 1 m in diameter. The body is hard, the root is not tuberous. Generally, the stems are wider than they are high.

The condition of *C. ahremephiana* varies significantly from year to year in response to rainfall. In 2001, plants were in the best condition for 5 years. In 2002 they were even better, benefiting from several rain events through the winter months. In spite of this, by 2003 they had degraded significantly. This species does not have a thickened taproot and cannot store nutrients and moisture underground. With



its relatively small stems, it is not very well adapted to withstand long dry periods, resulting in significant changes in condition from year to year.

The relationship of *C. ahremephiana* with other copiapoa species in the Botija valley is intriguing. One hypothesis, first proposed to me by Leo Van der Hoven (pers. comm., 2003), was that this species has may have originated from hybrids between *C. decorticans* and *C. atacamensis*, both of which only grow together in the Botija Valley. *C. ahremephiana* has spination similar to *C. decorticans* and has the white wax epidermis of *C. atacamensis*. Occasional F1 hybrids exist between *C. ahremephiana* and *C. atacamensis* as well as with *C. decorticans*, showing that the three species are compatible ⁽¹⁾.

C. ahremephiana appears to produce a few flowers through much of the year. Single bodied plants do not exist, indicating that reproduction has not occurred for many decades. Close inspection of the plants with three or four stems, reveals that these usually are the shrunk remains of far larger clumps which have died back to the strongest and youngest stems. It is doubtful if this species will survive for many more decades. The plants at the lowest elevations (50 m, near the coastal road) are now almost all dead. Even plants in the core areas above 400 m are degrading quickly.

In Europe this species has been incorrectly circulating in small numbers *C. rarissima* ⁽²⁾. Cultivated plants, including those grown from habitat collected seed, look markedly different (see photo below).



▲ A mature *C. ahremephiana* growing on the 500 m high hills to the north of the Botija Valley. Most visitors only examine the plants growing down on the alluvial deposits (grey areas). Plants also grow on the opposite slopes up to 400 m.

◀ A large cultivated plant of *C. ahremephiana*. Collection of Woody Minnich.



▲ A healthy *C. atacamensis* showing new spines.

▼ Leo Van der Hoven photographing a *C. atacamensis* near the summit of Botija Peak (1100 m).

C. atacamensis

(*C. boliviana*, *C. calderana* var. *atacamensis*)

C. atacamensis is known to occur from just north of the Iszuna Valley to as far north as the hills west of Mejillones. The northern population around Antofagasta and to the north is in poor condition with the exception of the very large population growing on the gently undulation summit of Cerro Moreno (800-1000 m). This population consists of approximately 200,000 individuals but almost all are mature clumping plants. Another thriving population of *C. atacamensis* occurs near the summit of Botija peak (1100 m). Both sites require several hours of strenuous walking to reach and are not normally visited by copiapoa tourists who are content to photograph immature and atypical plants at Blanco Encalada, inland from El Cobre, around Antofagasta or in the lower Botija Valley instead of walking and climbing to reach the remarkable large plants on their hilltop refuges.

Other populations are not so healthy. Inland from Antofagasta, there are plants at 600-900 m but these are more stressed than on the foggy Cerro Moreno. Additional small populations exist near the tops of the coastal cliffs south of Antofagasta at around 600 m elevation. The full distribution of *C. atacamensis* is not fully known, with



the area between Antofagasta and El Cobre being little explored. The northern extent of the population is also open but it is unlikely that other surviving population grow further north than the coastal hills near Mejillones. In the south, a small population of several dozen plants grows at the foot of Botija Peak near (24°33'27"S). These plants have apparently resulted from seeds washed down from the core population near the summit where there is a large population thriving.

In its core area, *C. atacamensis* is surviving well, with plants growing new stems and flowering regularly. Small, single headed plants are evident but not plentiful. No seedlings from recent decades were found. Most cactophiles visiting Chile only see isolated single headed plants of *C. atacamensis* and would not be aware of how large and impressive plants can grow in their core populations.

The suggestion that *C. atacamensis* is the northern form of *C. calderana* has some support, based on the similarity to the white stemmed *C. calderana* population (see page ???). *C. atacamensis* however, does not resemble Ritter's *C. calderana* (the *C. lembckeii* of cultivation) any more than several other species. If only geography, growth form, spination and epidermal characteristics are considered, it might be better to consider the white stemmed *C. calderana* as the



- ▲ A large stemmed example of *C. atacamensis*. The plants in the background are mostly dead *C. solaris*.
- ▼ When *C. atacamensis* are repeatedly grazed off, the new shoots remain small and tight to the ground. Compare this plant (tip of finger for size) with the mature plant on the opposite page.



southernmost population of *C. atacamensis* rather than the other way around. This would leave the name *C. calderana* to be used for the green bodies plants which match Ritter's original description.

Seedling *C. atacamensis* develop a sizable contractile taproot, allowing them to survive in an otherwise, hostile environment. During dry conditions, the root contracts, pulling the single head almost level with the soil, thus reducing water loss. Such seedlings are best seen (or used to be, before collectors raided the habitat), near Blanco Encalada where they grow among old and dying *C. solaris* on alluvial gravels at the base of the steep coastal hills. There are no larger *C. atacamensis* here and probably never were, as they prefer a much moister environment which is available only above 600 m.

Flowering of *C. atacamensis* is over a long period with ripe seeds being present on a few plants at every visit to the core populations. Shortly after rain, plants can quickly flower and rapidly set fruit. The fruits and seeds of *C. atacamensis* are among the smallest within the genus (a bit larger than *C. columna-alba*), allowing them to mature

▼ A healthy *C. atacamensis* from near the top of Botija peak.



quickly. This contrasts markedly with *C. solaris*, its habitat mate, which has the largest and slowest to mature fruits and seeds.

C. atacamensis grows with *C. solaris*, *C. tenuissima*, *C. aff paposoensis*, *C. decorticans* and *C. ahremephiana*. It hybridizes with *C. decorticans* and *C. ahremephiana*.



◀ A *C. atacamensis* growing from under a large *C. solaris*. Such healthy and vigorous plants are not easy to access by the casual copiapoa tourist. These plants grow on the saddle between Quebrada Botija and Quebrada Iszuna at 850 m elevation.

▼ A 'young' *C. atacamensis* with its root exposed. Note the narrow neck and the taproot. This plant was growing near the dry stream bed with most of its large root exposed.





▲ This *C. decorticans* has been in cultivation for five years and is showing new growth quite unlike the stems seen on habitat plants.

▼ A large mature plant of *C. decorticans* photographed during 2003. Note that a few of the smaller inner stems show new, light brown spines. The most recent growth is only from these younger stems.

C. decorticans

(the *C.* 'sp. Botija' of Schulz and Kapitany [1996])

Recently named by Taylor and Charles (Cactaceae Systematics Initiatives 13: 15, 2002), this species is quite unlike any other copiapoa. Rather than try and pigeonhole it in with better known species, it might be best to consider it to be a relict species whose closest relatives have all died out.

C. decorticans is more widespread than first thought. It grows to nearly 800 m on Botija Peak, and continues down into the valley and up along the northern hills for 5 km. It does not extend south into the Izcuna Valley nor does it extend inland further than 4 km.

Only mature plants remain, even in the core area which for this species appears to be the foggy 600-700 m zone on the north facing slopes of Botija Peak. Some plants look young but this is only because they have produced a few newer and shorter stems from the base of older plants after shedding their mature, decumbent stems.



During the wet year of 2001 we found no signs of flowering but there were some new spines on a few plants. In 2002 and 2003 there was some flowering which appeared to be seasonal, possibly October or November.

C. decorticans is handling the increased aridity better than the nearby *C. ahremephiana*. *C. decorticans* has a larger root system and body which retains moisture longer than the small stemmed *C. ahremephiana*. During the wet year of 2002, stems on larger plants were plump with a few plants having new spines. No single headed specimens were found. All small plants with few stems proved to be the remains of larger clumps which had died back. While this species is clearly destined for extinction, it will take longer to reach this point than the more vulnerable *C. ahremephiana*.

C. decorticans grows by itself except for along its margins where it may grow with a few *C. atacamensis* and *C. ahremephiana*. *C. decorticans* hybridizes with *C. atacamensis* (see comments under page ??)



This *C. decorticans* has grown new spines, forcing the wool out from the tight apex.

C. decorticans, showing new growth. Note the new stems coming out from the center of the plant. The woolly cactus in the upper right is *Eryiosyce paucicostata* ssp. *floccosa*.





▲ *C. solaris*, upper Izcuna valley. All the dark dots in the distance are clumps of this species.

▣ In the core area of *C. solaris* (the Botija saddle) plants are much more diverse (and also growing better) than in the usual sites visited by the casual cactus tourist. This plant exhibits straight, short and fewer spines than typical plants. Nearby were plants with bluish stems and highly curved spines.

▼ A few *C. solaris* have reddish flowers. Because of the dense apex spines, few flowers can open fully.



C. solaris

C. solaris is best known from its easily visited population inland from El Cobre, where it grows on both sides of the main road at 400-800 m elevation. Few people know that it also has several northern populations growing some 40 km north of Antofagasta. At one time, there were many tens of thousands of large clumps but almost all of these are now dead. The plants grow at the base of the coastal hills only 1-2 km east of the main north-south road and it is surprising that these plants have not been recorded earlier. Ritter made no mention of these populations which he would have undoubtedly passed during his travels during the 1960's and 1970's. During 2001 we were taken to the most northern known living plant by Dr. Gustavo Valdes, who had investigated the species north of Antofagasta for some time. I returned in 2002 to rephotograph the large survivor (see photo, page ??) which was still alive among hundreds of dead plants, only to find that a bulldozer had driven over the plant, crushing it completely. There may be a few more live plants in the vicinity but considering the large numbers of dead plants, which number in their thousands, this population will soon be extinct.

C. solaris may also form large populations between Antofagasta and El Cobre but the area's inaccessibility hinders exploration. In the south, the Izcuna Valley drainage system (at 24°39'40"S), supports the southernmost *C. solaris* which grow on a ridge just inland from



the ocean at around 950 m. The southern plant's habitat is very dry, with almost all other associated plants having died. From this point, an examination of the hills to the south with binoculars did not show any tell-tale dark brown hemispherical clumps which make this species so easy to spot at a distance. There are also no interior hills to the south where the habitat can be sheltered from direct fog. Based on this, I feel it is unlikely that additional populations of *C. solaris* exist south of the Izcuna Valley.

The core area for *C. solaris* is on the saddle (850 m) between the Botija and Izcuna drainage systems at (24°32'S). Plants do not grow on seaward facing slopes which are exposed to direct fog, rather, they grow best when sheltered behind Botija peak where the fog swirls over but not around them. Here, many *C. solaris* retain all of their stems with many clumps reaching over 2 m in diameter. This population extends over an area of about 2 km² and comprises several thousand healthy and growing plants. Even in the core area there are very few single headed 'seedlings'. The other non-succulent vegetation is showing signs of dying, indicating that this area is also becoming increasingly arid.

We did some investigations on the health of *C. solaris* during 1996 and while it is still too early to make another similar assessment (all our criteria for health were qualitative), it appears to me that plants



▲ An ant guarding a newly opened *C. solaris* flower. Ants appear to guard the flower until the nectar glands are open, releasing sweet liquid which will be gathered and taken back to the nest. Note how the flower is barely emerging from the apex.

▼ *C. solaris*, growing on the inland side of Botija Peak at 900 m. Note how the fog is swirling on the seaward side but not penetrating into the interior. Plants extend to almost the top of the hill (1150 m), where *C. atacamensis* grows in the more humid environment.





▲ *C. solaris* show variability in their core population on Botija Peak. This plant has quite curved spines.

▼ Remains of an old clump of *C. solaris* from 60 km north of Antofagasta. Even the wood from the massive root top had decomposed, leaving only the waxy remains of the epidermis. Such plants may have been dead for hundreds of years.

are dying throughout its range at an ever increasing rate. I was fortunate enough to be given some photographs by Pablo Weisser, who did an analysis of the biomass of a *C. solaris* population in the El Cobre area in 1972 (Weisser & Laubscher, 1993). I was able to relocate the position from where a photo was taken (see page ???). It is clear that during the thirty-two year period the area has seen a massive dying out of plants, with all but two of the then-healthy plants shown in the old photograph now dead. The GPS for this photo is given in the caption and I welcome copiapoa tourists to do their own photographic assessment over the coming years.

Recent visits have shed more light on the flowering and fruiting of *C. solaris*. During 2001, which followed a number of wet years, *C. solaris* showed signs of having flowered but few fruits were noted. During 2002, which was a wet year at Botija, *C. solaris* had no recent flowers but had produced some new spines and even small offsets on the healthiest plants. The early months of 2003 had abundant flowering, with many stems having dozens of old flower remains. Most flowers showed no signs of having been pollinated. Some unripe plump fruit contained no seed whatsoever. Older, dry fruit showed



heavy infestations of a grub which consumes the ripening seeds.

Growth of *C. solaris* during and after the el Nino years of 1997-99 was typical for other large stemmed copiapos. Some plants produced numerous offsets from stems, particularly where the stems were exposed to sunlight. By 2003, almost all of these offsets had died or been aborted into a dormant state, apparently because enough moisture was not available to keep them turgid. *C. solaris*.

C. solaris is the largest growing copiapoa, and most likely, the longest living. One exceptional plant, pictured below, was measured at just over 3.3 m in diameter and had 750 living heads. This plant, deserving of a pilgrimage by all dedicated copiapophiles, can be reached by following the Botija valley (south fork) to the top and then descending slightly into the Iszuna valley.

C. solaris grows mostly alone, however it can be found with *C. tenuissima* (at El Cobre), with *C. atacamensis* and *C. aff. paposoensis* and *C. humilis* var. *varispinata* (only in the Izcuna valley).



▲ A 'young' *C. solaris*, growing on a cliff face in bare rock. Considering the slowness of growth for this species, this plant may be hundreds of years old.

▼ A plant worthy of a pilgrimage! The author, at the largest *C. solaris* ever located. It has over 750 live heads. The furthest south *C. solaris* grows on Iszuna Peak, which can be seen in the far right distance.





▲ *C. tenuissima* from above El Cobre. Plants here are rare and usually buried in rock crevices where they are inaccessible to guanaco which have dug up and eaten all but the most protected plants.

▼ *C. tenuissima*, growing in a rock crevice on Botija Peak. This plant had few visible spines but showed signs of being chewed. All the heads come from one rootstock.

C. tenuissima

C. tenuissima is described as growing in the El Cobre area. Plants have always been rare, even during Ritter's day. Ritter commented that this species grows south to the hills above Blanco Encalada. There is no mention that suggest it is found further north than El Cobre but considering the inaccessibility of this area, it would not be a surprise if the species grows there in small numbers.

Today, the few remaining plants of *C. tenuissima* from long known populations are mainly found at 400-800 m where they grow among or at the base of large rocks. Here, they are protected from guanaco diggings and also receive some runoff from the infrequent heavy fog and drizzle. One small population of *C. tenuissima* (at around 400 m) is along the Nora Mine road inland from El Cobre. Less than 10 plants were found in 2001, none of these were relocated in 2003. We did find evidence of guanaco or donkey digging and suspect that the animals have eaten all of the stems. A single plant was located in 2003 growing at the base of a rock overhang where it was projected from predation. Ritter reported the same conditions in 1956 when he first discovered the plant. He mentions that few plants of flowering size were found and guanacos had resorted to eating all the more advanced stems. Other populations of *C. tenuissima* in the El Cobre





area are all not faring well because of predation by guanaco. While these animals are now quite rare in the area, they do move in from the south when the rare rain event brings some of the surviving shrubs and annuals into growth. It is then that the *C. tenuissima* are eaten.

During 2004, a healthy population of *C. tenuissima* was found on Botija Peak at 800-900 m. Here, among abundant *E. lactiflua* and *Eulychnia brevifolia*, plants grow in rock cracks as well as in loose soil in an area that receives heavy fog. While nibbled by guanaco, the plants themselves have not as yet been heavily dug around or eaten down to the roots, most likely because this area still supports a diverse array of more palatable plants. A few plants of *C. tenuissima* have also been reported to grow on alluvial fans at the base of western base of Botija Peak, where it is assumed they have spread to from their mountain core area.

Little is known about the flowering and seedling of habitat grown *C. tenuissima*. Because of its rarity and small size, it has been collected wherever found, further endangering its habitat numbers. Luckily, the



▲ Photographing a *C. tenuissima* on Botija Peak. Here, plants grow in a relatively lush environment among *C. atacamensis*, *Trichocereus deserticola*, *Eulychnia brevifolia* and woody shrubs.

▼ A *C. tenuissima* from the Miguel Diaz area. This plant was photographed in 2003 and was not relocated during 2004, even after a thorough search by ten people. The plant is assumed to have been collected (photograph: Woody Minnich)

▼ Close-up of plant being photographed above.





▲ *C. tenuissima* during a wet year. The spines have long ago been shed. This plant is identifiable as a copiapoa by its wooly apex.
(Photograph: Woody Minnich)

▶▶ A large *C. tenuissima*. The tops of the plants are level with the ground and when stressed, plants are difficult to spot by the casual observer.
Photo: Woody Minnich

Botija peak population is not easily reached and will hopefully remain free from greedy collectors.

Most plants labeled as *C. tenuissima* in cultivation look very different from habitat plants. While very attractive, it is assumed that these plants are hybrids, most likely with *C. humilis*.

C. tenuissima grows with *C. solaris* and *C. atacamensis*. Hybrids in habitat are unknown to me.



C. tocopillana

The habitat status of *C. tocopillana* is unclear. Ritter reports that he found it from Tocopilla to half way to Antofagasta. Dr. Lau reported finding substantial populations which he revisited in 2000. Few visitors to habitat during the 1990's have found more than a few scattered plants, all in an advanced stage of desiccation. One exception is RM Ferryman, who in *Islaya laui?*, (Chileans 98 p 95-97) comments that he found (during 1988) that *C. tocopillana* 'were evident and reasonably represented' on the hard climb to the *I. laui* site near Tocopilla.

The author has not visited the habitat for this species.



Above the mine at Esperansa, just south of Tocopilla there is a tramway of sorts which is used by miners to ascend up a gully to the higher hills. This steep gully eventually leads to a population of *C. tocopillana*.



C. tocopillana, inland from Tocopilla.

(photo: Tom Knappic)



▲ When first found, plants were very difficult to assess, appearing as balls of spines. Compare this picture with *C. tocopillana*, page ???.

◀ A large *C. aff. paposoensis* during the wet year of 2003. The ruler is 100 mm long.

▼ *C. sp. aff. paposoensis* during 2004 (a year without rain). Most plants have gray spines which have been bleached by the intense sun from this habitat that is seldom in the fog.

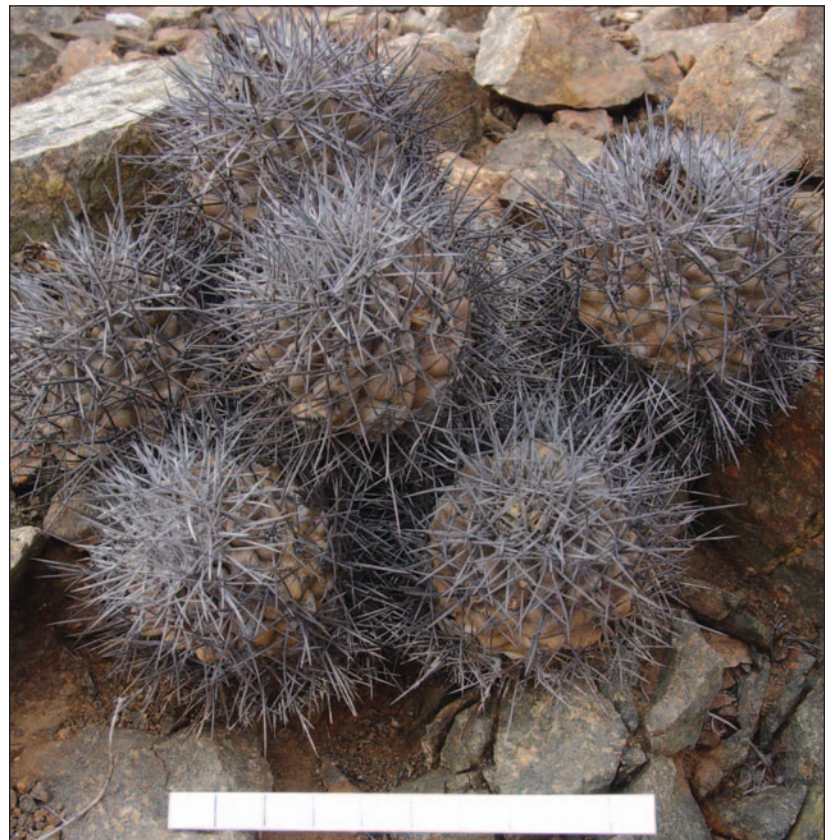


C. sp. aff. paposoensis

While exploring the area behind Botija Peak during 2001, a small but healthy population of copiapoas was located growing among *C. solaris* and *C. atacamensis* at 800-900 m. *C. sp. aff. paposoensis* occurs in a habitat that is the least degraded of any in the north. The habitat supports a large, healthy population of *C. solaris*, *C. atacamensis* and *Eulychnia brevifolia*. This location is about 20 km north of Ritter's type locality for *C. paposoensis*.

Plants form clumps with up to eight heads, which is far larger than the typical *C. paposoensis* population to the south. The body is usually brownish as opposed to the mostly green body of *C. paposoensis*. New spines are tan colored.

During dry years the spiny nature of the mature *C. sp. aff. paposoensis* makes it difficult to see the body and compare it to its most likely related species. Few plants are dead and mature plants appear not to have been predated on by guanaco and donkeys. Plants are very spiny and appear quite different than the related *C. humilis* var. *varispinata.*, which grows nearby and sometimes among plants of *C. sp. aff. paposoensis*. Juvenile offsets from the swollen taproot resemble *C. humilis*. Further investigations in the field and with seedlings (no seeds have yet been collected) are required to better understand



this plant's relationship with its nearest relative, *C. humilis* var. *varispinata* as well as Ritter's *C. paposoensis*, which is mentioned as growing as far north as the hills inland from Blanco Encalada.

No recent flowers or fruits were found, suggesting that *C. sp. aff. paposoensis* flowers seasonally, most likely in late spring. Young plants are not known. Dead or dying plants are rare, indicating that this population is faring as well as any other. This plant is not endangered and it is unlikely that collectors will ever have much of an impact on it considering the isolation of the population and the ordinariness of the plants.

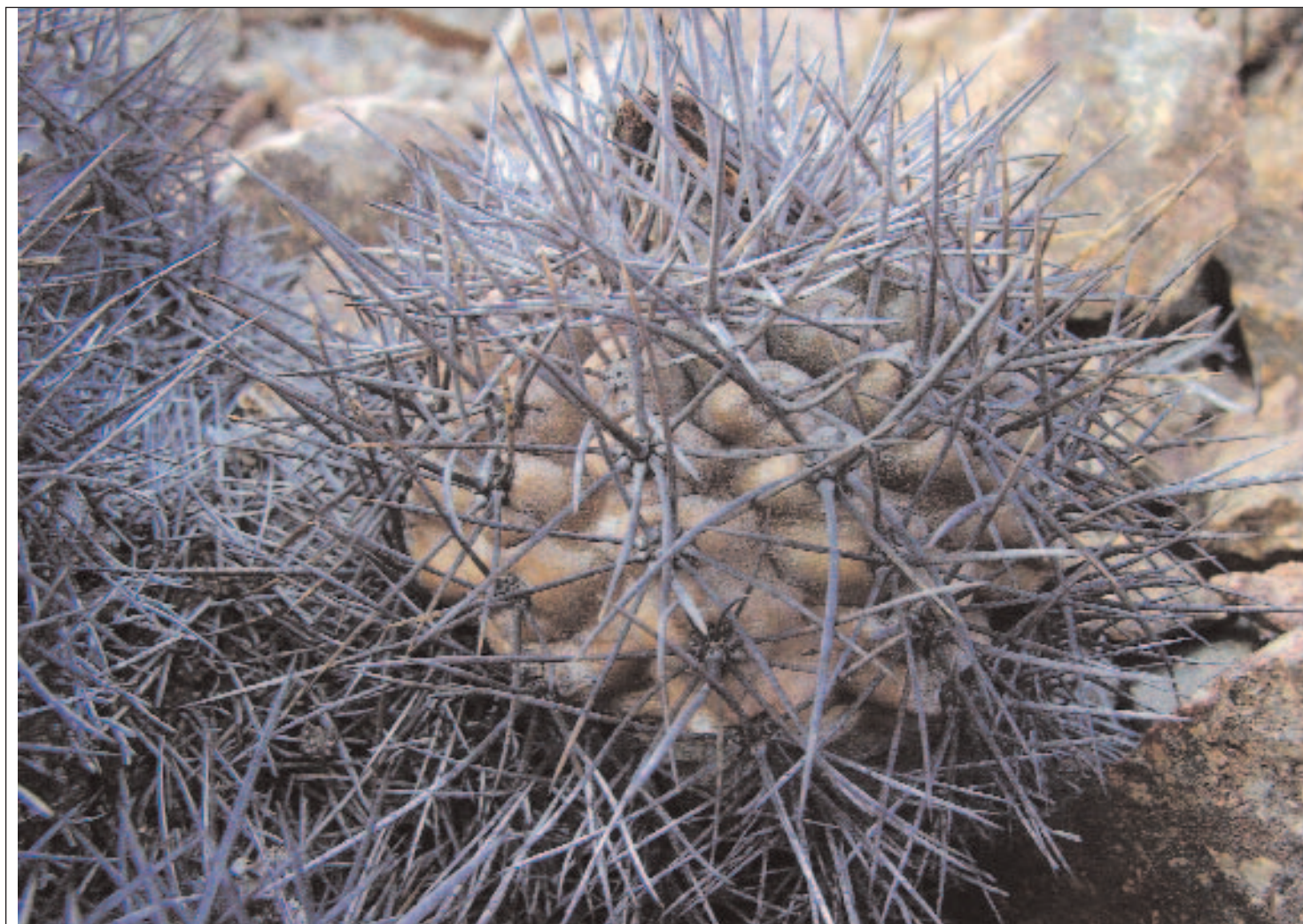
I feel that this population fits in with Ritter's concept of *C. paposoensis* but as this species is not currently recognized, further research is necessary to determine where it best fits among the currently accepted *Copiapoa* species. The population, is difficult to access and if there are further populations either to the north or south, they will be even more difficult to reach.

C. sp. aff. paposoensis grows with *C. solaris*, *C. atacamensis* and marginally with *C. humilis* ssp. *varispinata*. No hybrids were noted.



▲ Three plants of *C. sp. aff. paposoensis*, growing on fractured granite. They grow in a variety of soils.

▼ *C. sp. aff. paposoensis* during a wet year. Note how there are no distinct ribs, suggesting a close affinity with *C. humilis*.



Endnotes for chapter ?

(1) It has been suggested that *C. ahremephiana* is related to *C. cinerea* but no argument has been presented to support this view. The seedlings are very different from any of the *C. cinerea* complex. While some plants may look somewhat like stressed miniature *C. haseltoniana*, this is only the environment making stressed plants look similar.

(2) Ritter found *C. rarissima* growing on a flat coastal terrace in the Taltal area. The description of the type locality is very vague, being in the Department of Taltal (which extends south of Esmeralda). We searched likely areas to the south but found only isolated *C. rupestris* on the coastal terrace and *C. cinerea* ssp. *columna-alba* on the hilltops. Ritter claims that *C. olivana* gave successful pollination but *C. humilis* did not as it 'is from another section'. From this, I can only assume that this 'species' may have been the northernmost population of *C. grandiflora* or its hybrids. Ritter's 'population', from which he collected the only two remaining live plants, is now assumed to be extinct. One of these plants is assumed to have been used for his herbarium specimen (see page ???). The name *C. rarissima* has been incorrectly used in cultivation for *C. ahremephiana* and also for various hybrids.

Core areas and diversity

One of the features of core areas (see page ??) of a population is that here the species exhibits its fullest diversity of forms. As a general rule, the more stressed (and away from the core area) plants are, the more they look the same. This may partly be due to the fact that stressed plants show less body and more spines, making plants look alike, however diversity of spine features, stem length to diameter ratios and rib counts are all still visible, even in the most pulled in plants. To understand the full potential of a species' form, the features of the plants from the core area need to be considered. Unfortunately, sometimes species have been described from isolated, outlying populations which do not reflect the variability potential of the species, hence some of the problems we have today with interpretation of what should be included in the species.